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SWEEP OSCILLATOR
MAIN FRAME

MODEL 6600

Instruction Manual No. 110-6020

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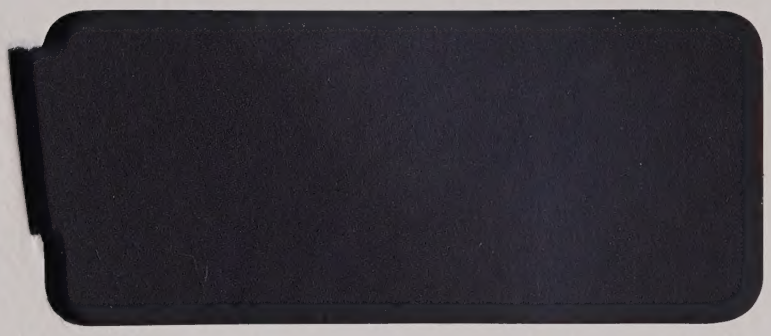

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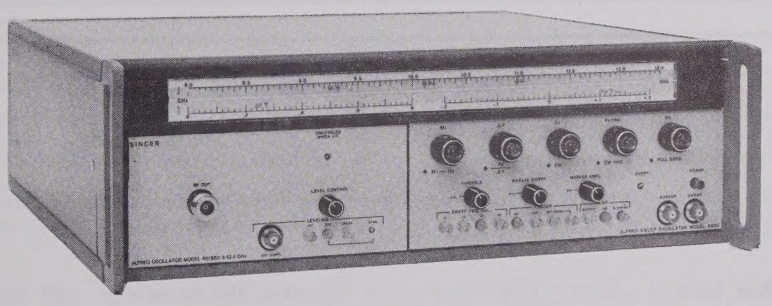

SINGER
INSTRUMENTATION

The Singer Company, Palo Alto Operation

3176 Porter Drive, Palo Alto, California 94304/ (415) 493-3231 TWX 910-373-1765

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WARRANTY

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REPAIR AND MAINTENANCE

Instruments should be returned only on prior written authorization from the Singer Representative or the factory(1). Please provide the following information in order to expedite our processing of your instrument:

1. Model or Type
2. Serial Number
3. Approximate date instrument was placed in operation
4. Approximate number of hours of use
5. Description of trouble(2)
6. Has maintenance action been previously requested?
7. Other comments

Upon receipt of this information our Service Department will send you service data or shipping instructions. Upon receipt of shipping instructions forward the instrument prepaid to the specified center or factory. If requested, an estimate of charges will be made before work begins.

(1) West Coast Service Center, 3211 S. LaCienega Blvd., Los Angeles, California 90016, Telephone (213) 870-2761, TWX 910-340-6352 for all Singer Instrumentation equipment; or Palo Alto Operation, 3176 Porter Drive, Palo Alto, California 94304, Telephone (415) 493-3231 TWX 910-373-1765 for Palo Alto Operation instruments.

(2) Include data on symptoms, measurements taken, test instruments used, suspected location of trouble, maintenance action taken, and any other relevant data.

MANUAL CHANGES

FOR

6600

Make changes and additions as indicated below:

CHANGE 1: Schematic 907481 and Parts List, Assembly A2; change value and listing of R29 from .27 Ω to Singer Part No. 44-.24 Ω, .24 Ω, ±5%, 1/2 W, fixed WW, 75042, BWH-.24 Ω - 5%.

CHANGE 2: Schematic 907471 and Parts List, Assembly A5.

A. Change value of C4 from 27 pF to "NOT ASSIGNED".

B. Change stock no. for U1 from 84-1 to 153-7056-001, true mfg. FSC no. to 11312, true mfg. part no. to 1319.

CHANGE 3: Schematic 106-0868-001 and Parts List, Assembly A6.

A. Change Singer Part No. for R45 and S12 from 71-168 to 71-178.

B. Change Singer Part No. for DS1 thru DS4 from 126-26 to 160-6014-001.

C. Change the value of C3 from .01 μF to "NOT ASSIGNED".

D. Change the true mfg. part no. for Q1 from MPSA14 to 2N3646.

E. Change CR4 to R28, 2.0 KΩ, ±1%, 1/4 W, MF, 59-2.0K, 19701, MF5C-D-2002F.

F. Change R14, 1 KΩ, to C14, 0.01 μF, GMV, 25 V, 12-56, 56289, HYS 20.

G. Change the value of R12 from 10 K to 4.99 KΩ, ±1%, 1/4 W, MF, 59-4.99K, 19701, MF5C-D-4991F.

H. Connect R46, 348 Ω to + 5 VR at top of schematic in series with CR10, LED, to ground.

I. Remove R22 from circuit. Short circuit C3.

J. Connect R11, 100 K, between pin 3 of S8 and ground.

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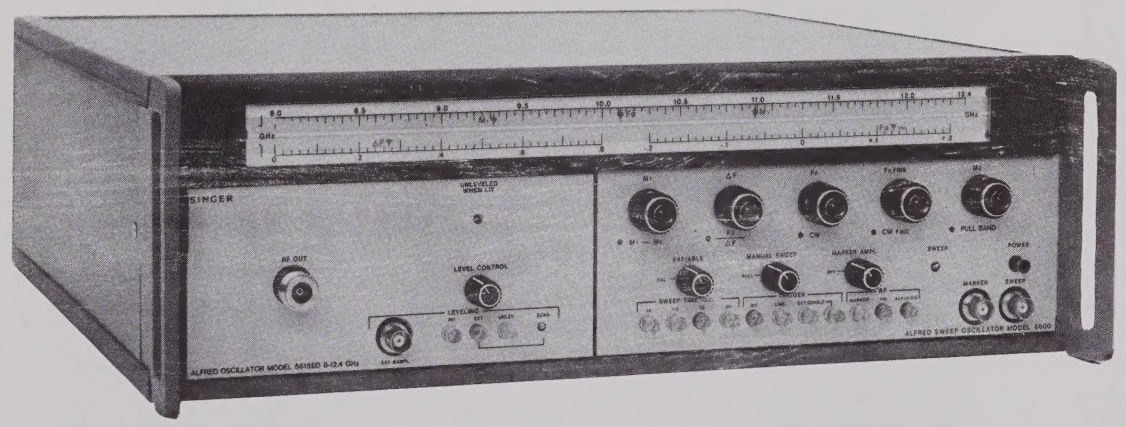


Figure 1-1. Model 6600 Sweep Oscillator

SECTION I
GENERAL INFORMATION

1–1. MODEL 6600 SWEEP OSCILLATOR.

1-2. The Model 6600 operates as a sweep oscillator when combined with any one of a family of Oscillator Plug-in Units, Models 6601 through 6616. The swept frequency output is a linear function of time, and both sweep width and sweep rate can be independently adjusted. In addition to swept RF, the instrument also operates as a single-frequency signal source, tunable anywhere in its frequency range, with stability rivaling that of mechanically-tuned signal generators. A large selection of Oscillator Plug-in Units covers the frequency range from 0.1 MHz to 18 GHz. The units are interchangeable, without adjusting or calibrating either the main frame or RF unit. All plug-in units are supplied with a linearly-calibrated frequency dial that is attached to the panel of the Model 6600 when that particular plug-in is used.

1–3. GENERAL DESCRIPTION.

1–4. SWEEP MODES.

1-5. The Model 6600 provides four sweep modes: three electronically controlled automatic sweeps (full band, narrow-band symmetrical sweep and marker sweep), and manual sweep. Full band sweep covers the full frequency range. During narrow-band symmetrical sweep (ΔF) operation, the frequency can be swept up to ±10% of the full frequency range about any desired center point (F_o). Marker sweep covers frequencies between Markers M1 and M2. All sweeps can be either free-running or triggered automatically from the line, an external trigger source, or a manual trigger. Sweep times are variable from .01 to 100 seconds. During Manual Sweep, the frequency can be manually tuned over the full range of the instrument or between preset marker frequencies. Three frequency markers are available in full band mode and two in ΔF mode. Markers appear as RF pips at the frequency selected. Video pulse markers are available at the MARKER connector for combination with an RF detector output display.

1–6. OUTPUT SIGNALS.

1-7. Several voltages are available for oscilloscope and recorder control. For X-axis deflection of oscilloscopes and recorders a zero to +10 V sweep voltage coincident with the RF sweep is available. Plus and minus 10 V blanking pulses are available during retrace. Also during retrace, for sweep times greater than 1 second, a relay with isolated S.P.D.T. contacts may be used to operate a recorder pen lift. The RF output may be either left on or turned off automatically during retrace.

1–8. MODULATION.

1-9. The RF output may be amplitude modulated by either an external signal or an internally generated square wave. The square wave frequency is continuously adjustable from 950 to 1050 Hz. There are also provisions for external frequency modulation. The RF output may be leveled across any of the bands. The leveling method and the leveling sampler depend on the plug-in used. See the applicable plug-in instruction manual.

1–10. THE OSCILLATOR PLUG–IN UNITS.

1-11. The Model 6600 is the main chassis, which contains the power supply, frequency control, and modulation circuits, and an opening for one interchangeable plug-in unit. The plug-in units contain the RF components. See the appropriate plug-in manual for specifications and operating instructions.

1–12. APPLICATIONS.

1-13. By offering both swept-frequency and stable fixed-frequency output, with many modulation and control options, the Model 6600 fulfills practically all requirements for microwave signal generation. It can be used to drive advanced swept-frequency test setups or for precision single-frequency tests. It can be amplitude modulated, pulse modulated, frequency modulated, and remote programmed to meet special systems requirements. Detailed operating instructions for use of the instrument in its various operating modes are given in Section 2. Contact the factory or your SINGER representative for information regarding special applications.

1–14. PLUG–IN MODULES.

1-15. Specifications for plug-in modules are shown in Table 1-3.

TABLE 1-1. SPECIFICATIONS

SWEEP AND SINGLE FREQUENCY CHARACTERISTICS	
Full Band Sweep:	Sweeps across full frequency range of plug-in.
Frequency Accuracy:	See plug-in specifications.
Marker Sweep:	Sweeps from M1 to M2 up or down in frequency. Continuously adjustab combination of start and stop frequencies.
Accuracy:	See plug-in specifications.
ΔF Symmetrical Sweep:	Sweeps upward in frequency about center frequency, F_o. Sweep width continuously adjustable on scale calibrated in MHz from 0 to 20% of frequency range.
ΔF Width Accuracy:	±2% of ΔF reading plus ±1% of maximum ΔF
Manual Sweep:	Adjusts frequency of output between sweep limits of full band, Marker, or ΔF sweep modes.
Sweep Time:	Continuously variable from .01 to 100 seconds per sweep in four ranges.
Sweep Triggering Modes:	
Internal:	Internally-triggered recurring sweep.
Line:	Recurring sweep synchronized with line frequency.
External:	External +5 volt trigger with 2 msec max. rise time activates sweep (rear panel).
Single:	Pushbutton activates single sweep. Second depression returns sweep to start on 10 second range. Externally applied ground contact stops and holds sweep.
Sweep Voltage:	DC-coupled sawtooth varying from 0 volts at start to +10 volts at end of sweep, regardless of sweep mode, width, or direction.
Voltage Proportional to Frequency:	In CW mode, voltage varies from 0 to +10 volts ±0.1V, in proportion to F_o frequency setting. DC-coupled output signal proportional to output frequency. Zero volts at lower end of band; +10 volts at upper end of band. Accuracy ±1% (rear panel)
Retrace RF Blanking:	Output power turned off. RF turned on prior to start of sweep to allow stabilization of external equipment.
Blanking Pulses:	+10 volts and -10 volts (±0.5 volts) during retrace (rear panel).
Pen Lift:	Relay contact open or closed during retrace (rear panel).
CW Frequency Vernier:	F_o fine tuning up to ±5% with F_o FINE; calibrated in MHz.
Accuracy:	±2% of maximum F_o FINE.
Spurious Signals:	See plug-in specifications.
Residual AM:	>50 dB below signal at 200 kHz from carrier at rated leveled power.
Frequency Stability:	With temperature: ±0.03% per degree Centigrade. With 10% change in line voltage: ±0.0002%. With change in output level: See plug-in specifications.

TABLE 1-1. SPECIFICATIONS (CONT.)

MARKER CHARACTERISTICS	
M1, M2, F_o Markers:	
Sweep Mode / Available Markers	Markers available as pip in RF and as sharp video triangle from front panel connector. Width varies with amplitude down to zero.
Full band: F_o, M1, M2	
ΔF: M1, M2	
M1 → M2: F_o	
Accuracy:	±1% of Dial Frequency.
Video Marker Amplitude:	0 to -5 volts. Z = 1000 ohms.
LEVELING CHARACTERISTICS	
Determined by Plug-in Unit. See Plug-in Unit Manual.	
MODULATION CHARACTERISTICS	
Internal Square Wave:	Continuously adjustable 950 - 1050 Hz. Rise time typically 50μsec. (Rear panel adjustment).
On/Off Ratio:	See plug-in PM specifications.
External On/Off PM (6601 and 6606 only):	+10 volts attenuates output by on/off ratio. See plug-in specifications (Rear panel).
External AM (all plug-ins except 6601 and 6606):	-5 volt attenuates output up to on/off ratio. See plug-in specifications. Z = 50 ohms. (Rear panel)
Modulation Sensitivity:	+10 volts or 1 kΩ potentiometer for full band deviation. Positive-going voltage increases frequency. (Rear panel)
External Sweep:	Input of 0 to +10 volts between pin 1 and 2 of connector J1 on rear panel increases Frequency of Plug-in output from zero to Full Band at DC to 100 Hz rate. This function is enabled via pin 13 of U1.
Frequency Modulation:	Available in most Plug-in units via connector in Plug-in unit Rear Panel. See Plug-in Unit Manual for characteristics.
OTHER CHARACTERISTICS	
Remote Digital Programming:	5 volt logic TTL and RTL or contact closures. See Option 5.
Accessories Furnished:	7-1/2 foot power cord with NEMA plug Rack mounting kit Instruction Manual Tilt Bail
Dimensions:	Overall Depth: 15-3/4" Depth Behind Panel: 15" Width: 16-3/4" Height: 5-1/4"
Weight:	Approximately 35 lbs., including plug-in.
Power:	115 or 230 volts ± 10%, 50/60 Hz; approximately 100 watts, including plug-in.

TABLE 1-2. OPTIONS

Option 1:	Rear RF Connector
Option 2:	Side panel carrying handle
Option 3:	Operation from 380 - 420 Hz power source
Option 4:	Included in all units.
Option 5:	Remote digital programming, TTL Compatible
Enable:	1 line binary
Band Selection:	4 line binary
Frequency Select:	12 line binary (1000 discrete frequencies), BCD
Enable Internal Square Wave:	1 line binary
Attenuator:	3 line binary (not available on 6601 or 6606D)

SECTION II
OPERATION

2–1. RECEIVING INSPECTION.

2-2. The 6600 Main Frame should be inspected for shipping damage as soon as received. It should be inspected for humidity and heat damage after any long storage period. Minimum performance tests should be made after each of these inspections.

CAUTION

Many adjustments within the Model 6600 chassis are critical. They were adjusted prior to shipment, and should not need field adjustment. Because of the interaction of these adjustments, complete realignment may be required if they are disturbed. See Section 4 of this manual before touching any internal adjustments.

2–3. PRELIMINARY INSPECTION.

2-4. Preliminary inspection of the equipment is performed on the Main Frame without operating power applied. This type of check detects conditions that might lead to a breakdown. Frequent causes of premature failure are overheating, due to improper ventilation or accumulation of dust and dirt, and/or loose connections and fittings. Inspection is carried out with emphasis on finding evidence of these conditions. Table 2-1 lists the preliminary inspection checks for the equipment.

2–5. POWER REQUIREMENTS.

2-6. The unit is normally connected at the factory for operation at 105 to 125 VAC (115 VAC nominal) and 50 to 60 Hz. To convert to 230 VAC (nominal) line power, remove the line power cord from the rear panel receptacle, and slide the plastic protective cover to expose the fuse. Remove the fuse, and slide the switch (with the arrow) to the 230 V position. Insert a new fuse.

NOTE

For 115 VAC, use a 1.6 A slow-blow fuse.
For 230 VAC, use a 3/4 A slow-blow fuse.

2-7. Slide the plastic cover back, and replace the line power cord in the receptacle. To reconvert for 115 VAC operation, reverse the above procedure.

2–8. CHASSIS GROUNDING.

2-9. The 6600 has a three-conductor power cord and a three-prong plug, which grounds the instrument when plugged into an appropriate receptacle. If a three-prong to two-prong adapter is used, ground the chassis by connecting the adapter pigtail lead to a suitable ground.

WARNING

Failure to ground the instrument properly can degrade its performance and stability, and could permit an above-ground potential on the chassis, which could be dangerous to operating personnel.

2–10. COOLING.

2-11. Adequate space must be provided at the top, rear and bottom of the unit for cooling purposes. Although forced air cooling is provided, space for flow of the cooling air is required. Allow one-inch at the rear and top and one-half inch at the bottom.

2–12. INSTALLATION AND REMOVAL OF PLUG–IN UNIT IN THE MODEL 6600.

CAUTION

When changing Plug-in Unit, turn the POWER switch off and wait 15 seconds before removing the Plug-in Unit, to permit decay of the power supply voltages. Do not insert Plug-in Unit into the 6600 with the 6600 power turned ON.

2–13. REMOVING PLUG–IN UNIT.

2-14. Pull out the black leve at the left of the Plug-in. This will cause the Plug-in to move out of the 6600 panel. Remove the Plug-in by holding the edges of its front panel and pulling it out of the 6600.

2–15. INSTALLING PLUG–IN UNIT.

2-16. Push the Plug-In into its receptacle until the black lever is forced down, then up a little. Push the black lever up to be almost flush with the 6600 and plug-in panels. The front panels should be flush. Several pounds force may be required to push the lever in.

2–17. FREQUENCY DIAL INSTALLATION.

a. Select the frequency scale corresponding to the range of the appropriate plug-in unit.

b. Place the beveled edge at the left end of the frequency scale under the lip at left end of the Model 6600 frequency dial.

c. The corresponding lip at the right end of the Model 6600 frequency dial is spring loaded. Slide it about 1/4 inch to the right, and place the frequency scale in position over the frequency dial. Two plastic pins are spring loaded to force the dial out for removal. Push them flush with the dial, when mounting it.

TABLE 2-1

PRELIMINARY INSPECTION CHECKS

Item	Inspect For	Corrective Action
Connectors	Looseness, bent or corroded contacts, signs of arcing	Clean contacts with cloth moistened with cleaning solvent trichloroethylene or equivalent. Replace connectors if damaged or deeply corroded.
Main Frame and front panel	Dirt and corrosion	Clean with cloth moistened with cleaning solvent trichloroethylene or equivalent.
Knobs, screws, connectors, clamps	Looseness	Tighten using appropriate torque so as not to strip threads.
Switches	Looseness	Tighten mounting screws or nut.
Wiring	Looseness	Resolder, recable, or reclamp.
	Frayed, worn, or missing insulation	Replace as required.
Solder joints	Loose or cold solder connections; corrosion	Clean carefully and resolder, using recommended soldering iron.
Printed circuit boards	Mounting looseness	Replace mating plug if required.
	Loose components	Resolder loose components.
Resistors	Cracks, chipping, blistering, discoloration, and other signs of overheating	Replace with exact match or original.
Capacitors	Leaks, bulges, signs of aging	Replace capacitor.
	Loose mounting bracket	Tighten nuts or screws holding bracket.
Switch contacts	Dirt, dust, and/or corrosion	Clean with cloth, aerosol spray, syringe or camel-hair brush using trichloroethylene or equivalent.
	Bent or broken contacts	Replace switch wafer or assembly.
Transistors	Looseness	Seat firmly in sockets, or resolder leads to etched circuit.

d. Release the sliding lip and check to be sure that the scale is secure. There is a calibration line on the frequency scale. This should coincide with two dots on the 6600 frequency dial. If it does not, adjust its position by turning the screwhead to the left center of the frequency scale.

2–18. CONTROLS, INDICATORS AND CONNECTORS.

2-19. The front panel controls, indicators and connectors for the 6600 are illustrated in Figure 2-1 and described in Table 2-2. Similarly, the rear panel is shown in Figure 2-2 and described in Table 2-3.

2–20. TEST EQUIPMENT REQUIRED.

2-21. The test equipment required for the maintenance of the Main Frame is listed in Table 2-4. If the recommended model numbers specified are not available, equivalent models may be substituted.

2–22. MINIMUM PERFORMANCE STANDARDS.

2-23. The minimum performance standards tests provide a systematic procedure for determining if the Main Frame is operating within the specifications listed in Table 1-1. Should the Main Frame fail to provide the specified "acceptable indication", the equipment is not functioning properly and the operator should refer to the applicable troubleshooting or alignment procedures to return the equipment to proper operating condition. Set the Main Frame controls as listed in Table 2-5 prior to initiating the minimum performance standards tests detailed in Table 2-6. These tests assume the use of a correctly calibrated plug-in.

2-24. If a plug-in meets specifications with the Model 6600 under test, it can be assumed that the Model 6600 meets specifications.

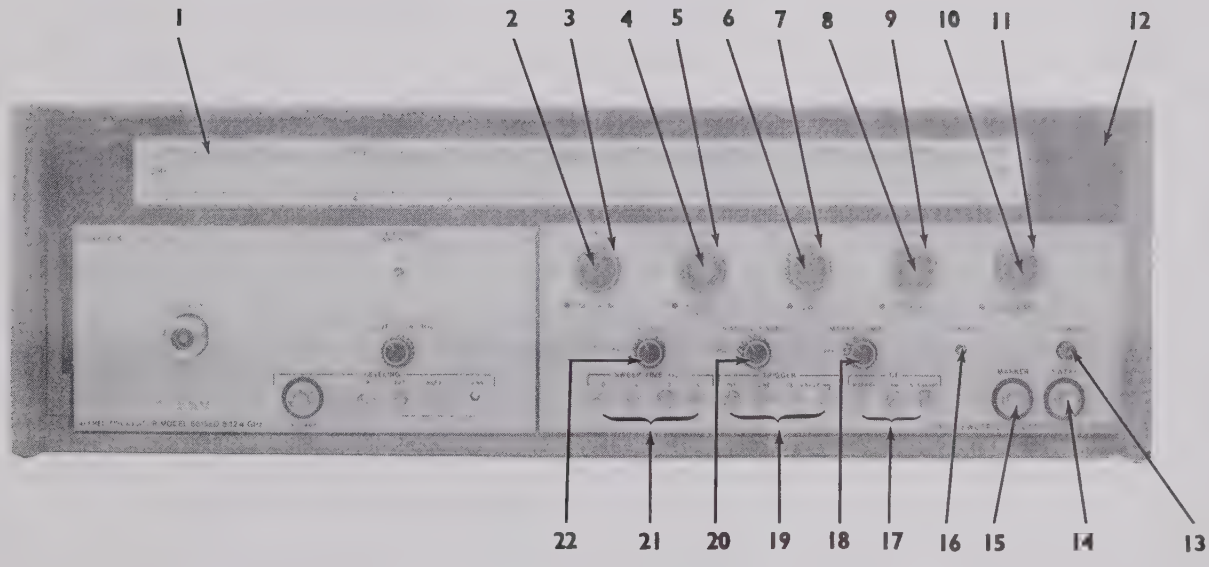


Figure 2-1. Model 6600 Front Panel Controls, Indicators and Connectors.

TABLE 2-2. MODEL 6600 FRONT PANEL CONTROLS, INDICATORS, AND CONNECTORS

Index No. Figure 3-1	Control, Indicator or Connector	Function
1	Calibrated Frequency Dial	Provides a calibrated means of setting frequency for the various sweep modes. The dial is calibrated to cover frequency range of particular plug-in unit in use.
2	M1→M2 pushbutton	Enables frequency sweep between dial settings of markers M1 and M2. Markers are enabled in full band, external sweep, external FM and ΔF modes. Pushbutton lights when depressed.
3	M1 control	Permits tuning of M1 dial pointer and M1 video and RF markers to any frequency in the band. Determines start frequency of the M1 → M2 sweep.
4	$\frac{F_o}{\Delta F}$ pushbutton	Enables ΔF narrow-band sweep operation where the unit sweeps symmetrically upward in frequency about F_o center frequency. Pushbutton lights when depressed.
5	ΔF control	Permits moving of ΔF dial pointer and controls width of upward frequency sweep about F_o center frequency. Maximum sweep width is 20% of full band.
6	CW pushbutton	Enables single frequency (continuous wave) RF output at any point across full band. Pushbutton lights when depressed.
7	F_o control	Permits moving F_o dial pointer and controls F_o center frequency in ΔF sweep mode, RF output frequency in CW mode, F_o marker in full band, external sweep, FM and marker sweep modes.
8	CW FINE pushbutton	Enables fine F_o frequency adjustment by F_o FINE vernier control in CW fine mode. Pushbutton lights when depressed.
9	F_o FINE control	Controls F_o center frequency, 0 to 5% either side of F_o for precise (vernier) frequency adjustments.
10	FULL BAND pushbutton	Enables full band mode, sweeps across full frequency range of plug-in. Pushbutton lights when enabled.
11	M2 control	Permits moving M2 dial pointer and M2 video and RF markers to any frequency in the band. Determines stop frequency of the M1→M2 sweep.
12	Frequency Dial Retainer	Spring loaded retainer that releases calibrated dial scale for replacement when plug-in with different frequency range is installed.
13	POWER pushbutton	Permits ac line power to be applied to unit.
14	SWEEP connector	Provides a 0 to +10 volt sawtooth output voltage synchronized with RF output frequency. In CW mode, voltage varies from 0 to +10 volts in proportion to F_o and F_o FINE frequency settings.
15	MARKER connector	Provides a triangular video pulse, 0 to -5 volts peak for each marker.
16	SWEEP indicator	Lights during sweep time in internal sweep modes. Light goes out during retrace, manual sweep, external sweep, and external FM or CW modes.
17	RF pushbuttons	
	BLANKING pushbutton	Removes RF output during sweep retrace. Pushbutton lights when depressed.
	AM pushbutton	EXT/INT Switch on Rear Panel, Table 2-3. Pushbutton lights when depressed.
	MARKER pushbutton	Enables RF marker mode which modulates RF output such that pips appear at RF output to indicate M1, M2, and F_o marker frequencies. Pushbutton lights when depressed.

TABLE 2-2. MODEL 6600 FRONT PANEL CONTROLS, INDICATORS, AND CONNECTORS (CONT.)

Index No. Figure 3-1	Control, Indicator, or Connector	Function
18	MARKER AMPL/OFF control	Controls the amplitude of the marker pips at the RF OUT connector and video markers at the MARKER connector. Marker amplitude is adjustable from 0 volts in the counterclockwise position, to -5 volts in the fully clockwise position.
19	TRIGGER pushbuttons	MANUAL SWEEP control must be set to OFF for the following trigger mode functions.
	EXT/SINGLE pushbuttons	EXT pushbutton enables SINGLE pushbutton to initiate manual single sweep X-Y recordings, if SWEEP TIME pushbuttons are set for 10 seconds. SINGLE pushbutton can also reset sweep any time during sweep. EXT pushbutton enables external triggering of sweep at rear panel.
	LINE pushbutton	Enables triggering of sweep synchronously with line power frequency. Pushbutton lights when depressed.
	INT pushbutton	Enables free-running, continually recurring sweep that is triggered upon completion of the preceding sweep.
20	MANUAL SWEEP/TRIG control	In SWEEP OFF position, all trigger functions are determined by the TRIGGER mode pushbuttons. In MANUAL SWEEP the trigger functions are disabled and frequency is controlled manually by rotation of the MANUAL SWEEP control. Manually controls within sweep limits of full band, marker or ΔF sweep modes.
21	SWEEP TIME (SEC) mode pushbuttons	Select one of four sweep ranges whose sweep time is continuously adjustable by the VAR/CAL vernier control for overall sweep time tuning from 10 msec up to 100 seconds.
	.01 pushbutton	Enables continuously variable sweep time from 10 msec to 100 msec. Pushbutton lights when depressed.
	.10 pushbutton	Enables continuously variable sweep time from 100 msec to 1 second. Pushbutton lights when depressed.
	1.0 pushbutton	Enables continuously variable sweep time from 1 to 10 seconds. Pushbutton lights when depressed.
	10. pushbutton	Enables continuously variable sweep time from 10 to 100 seconds. Pushbutton lights when depressed.
22	VAR/CAL control (vernier)	
	VAR position	Provides vernier adjustment of sweep time from minimum (X 1.0) to maximum (X 10) of sweep range selected at SWEEP TIME (SEC) mode pushbuttons. For example, .01 SWEEP TIME (SEC) is adjustable from 10 msec to 100 msec sweep time.
	CAL detent position	Provides calibrated sweep. The sweep time that is marked is generated each time a sweep is triggered. For example, in the .01 sweep time range, a .01 second sweep is triggered each time.

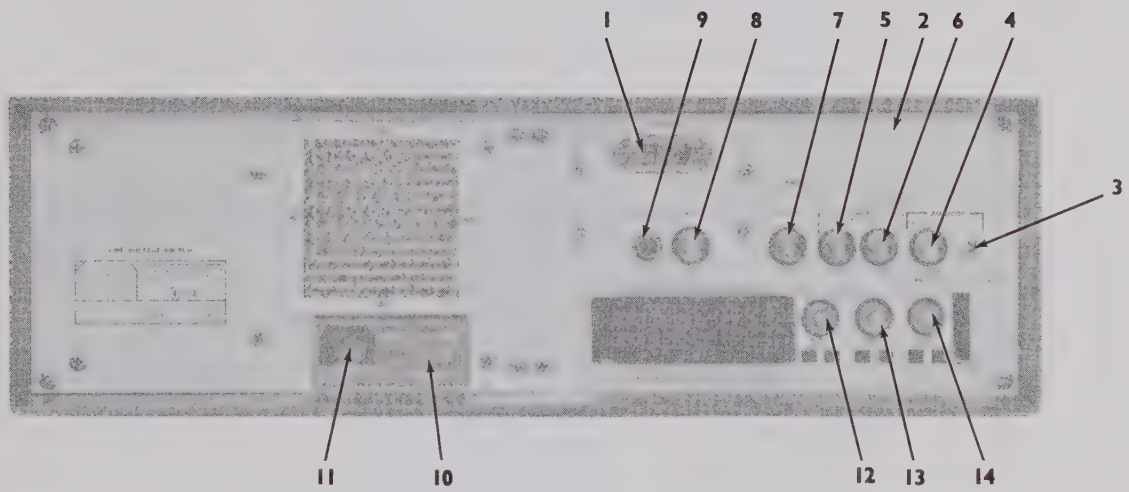


Figure 2-2. Model 6600 Rear Panel Controls and Connectors.

TABLE 2-3. MODEL 6600 REAR PANEL CONTROLS AND CONNECTORS.

Index No. Figure 3-2	Control, Indicator, or Connector	Function
1	J1 REMOTE connector	Provides a means of remotely controlling certain operational functions. Remoted functions can, depending on programming, override front panel control.
2	J8 COMPUTER connector position	Provides a means of controlling by digital computer most operational functions. When properly programmed the computer can completely override both front panel controls and remotely controlled functions at J1.
3	AM MODE	
	EXT/INT switch INT position	Applies internally generated 1 kHz square wave to the plug-in unit which pulse modulate the RF output signal.
	EXT position	Permits an external modulation signal, if applied to AM connector J12, to modulate the RF output signal.
4	AM connector	Input connector for applying an external modulation signal for modulating RF output signal. To turn RF on requires +4.5 volts or an open circuit. To turn RF off requires 0 volts or ground source which will sink 5 mA of current (see warning following paragraph 3-34).
5 6	+BLANK connectors - BLANK connectors	Output connectors for +10 volts and -10 volt blanking pulses for oscilloscope blanking. Blanking occurs during dwell and retrace periods. Front panel RF BLANKING pushbutton does not affect this output (see note following Paragraph 3-32).
7	TRIG IN connector	Input connector for external trigger input from remote source. Sweep is triggered when input trigger pulse is +5 volt pulse with 2 μs (minimum) duration. External triggering is enabled by the trigger EXT pushbutton on the front panel with MANUAL sweep control in OFF position.
8	VpF connector	Output connector for dc coupled VpF (voltage-proportional-to-frequency) varying from 0 to +10 volts across full band.
9	1 KHz ADJ control	Controls frequency of internal 1 kHz square wave generator. Adjusts output between 950 and 1050 Hz in internal AM mode.
10	AC power line fuse/switch	
	115 VAC position	Connects unit for 115 VAC line operation, that is safeguarded by 1.6 - ampere slow-blow fuse.
	230 VAC position	Connects unit for 230 VAC line operation, that is safeguarded by 0.8 - ampere slow-blow fuse.
11	AC power cord receptacle	Provides plug-in receptacle for AC power cord connected to main AC power source.
	Plug-In Connectors (Model 6615ED)	
12	Network Analyzer	Sweep Signal for Network Analyzer
13	Frequency Modulation	FM Input
14	Amplitude Modulation	AM Input

TABLE 2-4. RECOMMENDED TEST EQUIPMENT

Test Equipment	Critical Specifications	Manufacturer and Model
Plug-In Generator	Provides RF when plugged into 6600.	SINGER 6601 through 6616, 9514/9515
Network Analyzer	At least 100 kHz to 18 GHz, -40 dBm to +20 dBm.	SINGER 8000/7051
Frequency Counter	At least 100 kHz to 18 GHz, Sensitivity <4 mW.	Systron-Donner 1038/1253
Oscilloscope	Sweep from < 10 msec to > 60 sec, External Trigger.	Tektronix 531Z/533A
Oscilloscope Plug-in	Sensitivity: 50 μV or less/cm Frequency: DC to 10 MHz	Tektronix Type 1A7
Power Meter and Thermistor Mount	Power Range: 100 μW to 10 mW	HP431 with 478A Thermistor Mount
Digital Voltmeter	Accuracy ±0.004%, 1 mV - 200V	HP3460
Crystal Detector Set	10 MHz - 12.4 GHz, matching Singer Model 8000/7051	SINGER 1403
Directional Couplers	10 - 1000 MHz, 10 dB 1.0 - 4.2 GHz, 10 dB 3.0 - 12.4 GHz, 10 dB	SINGER 1170-10-2 SINGER 1173-10
Marker Generator	100, 25 and 5 MHz Marker	SINGER 7300
Pulse Generator	Rise and Fall Time: < 13 nsec Rep. Rate: 10 Hz to 10 MHz	HP241A
Service Kit for Model 6600(A) Containing:		SINGER P/N 102-0200-001
1 - Model 6602 Test Plug-in	To match 6600(A), with voltage switching and loads.	103-2701-001
1 - Model 6602A Extender Plug-in	To match 6600(A) and Plug-ins	952-910
1 - PCB Extender, non-heatsink	To match non-regulator PCB's of 6600(A)	103-2230-001
2 - Extension Cables DIP connectors	DIP plugs on 12" flat cable	102-9205-001
1 - Extension cable, Power Supply	Male, female cable to match A1	102-9206-001

TABLE 2-5. CONTROL POSITIONS AT START OF MINIMUM STANDARDS PERFORMANCE TESTS

RF Control Switches:	M1 → M2 ON	
M1:	Minimum Frequency	
M2:	Maximum Frequency	
Sweep Time:	0.01 sec	
VERNIER:	Counterclockwise	
Trigger:	Internal	
Manual Sweep:	Depressed (OFF)	
RF:	BLANK	

TABLE 2-6. MINIMUM PERFORMANCE STANDARDS

Step	To Check	Test Procedure	Acceptable Indication
1	Operation of Power Control	Plug-in appropriate plug-in unit. Verify 115/230 switch on rear panel is set for available voltage. Connect power cord to power source.	Fan may be ON or OFF. Dial lights may be ON or OFF. If OFF push power switch button to turn ON.
2	Leveled Output of Plug-In Unit	Connect wattmeter to RF output jack of plug-in unit. Set controls as follows: Manual Sweep: OFF Trigger: INT Sweep Time: FAST Sweep Width: Full Band Leveling: INT Level Control (Plug-in): Max.	RF wattmeter reading is at least minimum leveled output of plug-in specification, less 1 dB (20%).
3	Level Control	With setup of Check 2, vary Level Control.	Output varies with setting of Level control, per plug-in specification.
4	Sweep Frequency of RF output of Plug-in	Connect Marker Generator and oscilloscope to RF output of plug-in, as directed in Marker Generator manual. Set controls as shown in Check 2, with oscilloscope set to match. Vary M1 and M2 frequencies.	Evenly spaced markers across scope face, with end markers indicating bottom and top frequencies of Full Band. Same to match any positions of M1 and M2 at ends of sweep.
5	ΔF Control	Turn ΔF ON. Vary ΔF setting.	Markers should indicate frequencies of output. Match F_o and ΔF dial settings.
6	Constant Frequency Output	Connect frequency counter to RF output of plug-in unit. Switch to CW and vary F_o position.	Output frequency matches frequency dial position of F_o.
7	Manual Sweep	Turn manual sweep ON. Measure RF out with counter.	Frequency should vary across selected band as manual sweep control is turned.
8	Sweep Speeds	Use calibrated oscilloscope to observe outputs at +Blanking or - Blanking, for SWEEP TIME 0.01, 0.1, and 10 sec. Vary position of VERNIER control	Unblanked time of sweep on scope should vary from 10 msec to 100 sec. Calibrated sweeps should match setting ±10%.
9	Line Trigger (INT Trigger Tested in Step 2)	Set controls for LINE trigger. Monitor +BLANK with oscilloscope synchronized to the AC line. Vary sweep times.	Blanking signals should appear, synchronized with the AC line. Sweeps will occur at 40 per second for short sweep times. (10 msec sweep plus two 4 msec dwell times > period of 60 Hz). Synch trigger is 120 pps.
10	EXT/Single Trigger	a. Set SWEEP on 10 sec. Monitor +BLANK. Push EXT button. Feed slow trigger (<+5V) into TRIGGER IN (rear panel). b. Disconnect externally trigger. Push single button, repeatedly.	a. Blanking signal should match TRIGGER IN timing. b. Blanking pulse should appear one sweep time after button is pushed. If button is pushed a second time, before the sweep time is completed, a Blanking pulse should appear immediately.
11	SWEEP Output	Connect oscilloscope to sweep jack.	Sweep voltage varies from zero to +10 V during period set by TIME (SEC) pushbutton. It varies from 0 to +10V in proportion to F_o and $F_o/\Delta F$ settings, in CW mode.
12	Amplitude Modulation	Monitor detected output of Fixed Frequency (CW) Signal. a. Push AM button. Switch rear panel AM switch to INT. Vary position of 1 kHz control on rear panel.	a. Output, on scope, should be 1 kHz square wave, varying ±50 Hz with position of 1 kHz control, from near zero power to normal leveled power.

TABLE 2-6. MINIMUM PERFORMANCE STANDARDS (CONTINUED)

Step	To Check	Test Procedure	Acceptable Indication
12	Continued	b. Push AM button. Switch rear panel AM switch to EXT. Connect positive pulse signal (<5V) to PM connector.	b. Scope should shown pulses similar to input pulses.
13	PEN LIFT Outputs	Monitor PEN LEFT outputs, plus and minus. Set SWEEP on SLOW, trigger on INT. Sync scope to blanking.	PEN LIFT contacts to ground should match (NO) Blanking pulses or be opposite (NC) to blanking pulses.
14	Markers	Turn Markers ON. Monitor detected RF and Marker output.	Pips on RF and Marker output should match M1, M2, F_o settings. Maximum Marker output should be at least -5 volts.

2-25. OPERATING INSTRUCTIONS.

2-26. TURN-ON PROCEDURE.

To turn on the 6600, proceed as follows:

a. Ensure that rear panel 115-230 V switch is set for the correct line voltage. Check also for the correct fuse rating (see Paragraph 2-5).

b. Ensire that RF plug-in unit is installed and secure before applying power.

c. Connect line cord to power source.

d. Press POWER pushbutton to apply power, and ensure that blower fan is operating and dial lights are lit.

e. Allow the equipment to warm up for at least 15 minutes.

2-27. SWEEP FREQUENCY OPERATION.

2-28. There are three recurring sweep modes and a manual sweep mode. The recurring sweep modes are:

Full Band
Marker Sweep
ΔF Narrow Band Sweep

2-29. FULL BAND SWEEP.

2-30. In full band sweep mode, the unit sweeps across the entire frequency range of the plug-in unit. The sweep is in the direction of increasing frequency with all markers (M1, M2 and F_o) present at the RF output of the plug-in. Full band sweep is convenient for quick testing over an entire band. For full band sweep, set the controls as follows:

a. FULL BAND pushbutton: depress. Observe that respective indicator lights.

b. RF BLANKING pushbutton: depress, if RF output is to be off during sweep retrace. Observe that respective indicator lights.

c. SWEEP TIME (SEC) pushbuttons: Select and depress for desired sweep time range. Observe that respective indicator lights.

d. SWEEP TIME VAR: Set for desired sweep time. Note that CAL position (fully counterclockwise) is for calibrated sweep time equal to SWEEP TIME (SEC) selected.

e. TRIGGER mode pushbuttons: Depress for desired sweep trigger mode.

f. Read marker positions at top scale of frequency dial. Adjust marker amplitude using the MARKER AMPL control. Use the MARKER pushbutton to enable RF marker generation. Video Markers are not controlled by the MARKER pushbutton.

2-31. MARKER SWEEP.

2-32. Marker sweep mode is similar to the full band sweep mode but is convenient for testing over narrower portions of the band. The marker sweep start and stop points can be set anywhere within the band for either a frequency upsweep or downsweep. The sweep always starts at M1, and stops at M2. To operate the Marker Sweep, for example, to bracket the sweep about any portion of the band, proceed as follows:

a. Using M1 and M2 controls, set markers (read at top scale of frequency dial) to the desired sweep start and stop points. For downsweep, set M1 above frequency of M2. Conversely, for upsweep set M1 below frequency of M2.

b. Depress M1 → M2 pushbutton to enable the marker sweep mode.

c. Set the sweep time, blanking, etc., controls for convenience, as in full band sweep. Note that only the F_o marker operates in Marker sweep mode.

d. Activate RF marker generation by pressing the RF MARKER pushbutton. Adjust the marker amplitude with the MARKER AMPL control.

e. To disable marker generation, turn MARKER AMPL control to OFF or press RF MARKER pushbutton off to disable RF marker only.

2-33. ΔF NARROW BAND SWEEP.

2-34. The ΔF sweep is a narrow-band sweep that is symmetrical about the F_o center frequency. The ΔF sweep extends from $-\Delta F/2$ to $+\Delta F/2$ about F_o as read on the ΔF scale. Maximum sweep width is 20% of the full band. The F_o and ΔF controls operate independently of one another and can be reset during narrow-band operation to obtain the desired ΔF window at the desired F_o center frequency. To operate in ΔF mode, proceed as follows:

a. Press $\frac{F_o}{\Delta F}$ pushbutton to place unit in narrow-band sweep mode.

b. Adjust ΔF control to desired narrow-band sweep width as read on ΔF scale.

2-35. Other control arrangements and auxiliary output signals are essentially the same as for marker or full band sweep. However, note the following differences:

1) The F_O marker is inoperative, but the M1 and M2 markers operate just as in full band sweep. See Paragraph 3-9.

2) The sweep time controls set the sweep time from $-\Delta F/2$ to $+\Delta F/2$.

3) The VpF (voltage-proportional-to-frequency) output in the ΔF mode is 2 volts or less, peak-to-peak, since the frequency band is no wider than 20% of full band. Thus, when the sweep mode is switched from full band to ΔF, the sweep output ramp remains at 10.5 volts, but the voltage-proportional-to-frequency output decreases. The front-panel SWEEP indicator light is ON for the duration of each sweep from Fo $-\Delta F/2$ to Fo $+\Delta F/2$.

2-36. SWEEP TIME SELECTION.

2-37. The SWEEP TIME (SEC) mode pushbuttons control the time required for one complete sweep. There are four calibrated sweep times when the VAR control is set fully counter-clockwise to CAL. When the VAR control is turned clockwise from CAL, it increases the sweep TIME (decreases sweep speed) up to 10:1, when set fully clockwise. Thus, sweep time is continuously variable from 0.01 to 100 seconds through four sweep ranges. The 0.01 and 0.1 second ranges are most convenient for oscilloscope display; the 1.0 second range for small strip chart recorder readout; and the 10 second range for X-Y recorder readout. The 100 second sweep can be used for special applications such as measurement of output power or modulation characteristics with external meters. To select the desired sweep time, proceed as follows:

a. CALIBRATED SWEEP. Set CAL/VAR control to CAL detent position for calibrated sweep.

b. For 10 msec calibrated sweep, press the .01 SWEEP TIME (SEC) pushbutton.

c. For 100 msec calibrated sweep, press the .10 SWEEP TIME (SEC) pushbutton.

d. For 1 sec calibrated sweep, press the 1.0 SWEEP TIME (SEC) pushbutton.

e. For 10 sec calibrated sweep, press the 10. SWEEP TIME (SEC) pushbutton.

f. UNCALIBRATED SWEEP. Rotate CAL/VAR control clockwise from CAL detent position.

g. For 10 msec to 100 msec sweep, press the .01 SWEEP TIME (SEC) pushbutton and adjust VAR control to desired sweep.

h. For 100 msec to 1 sec sweep, press the .10 SWEEP TIME (SEC) pushbutton and adjust the VAR control to desired sweep.

i. For 1 sec to 10 sec sweep, press the 1.0 SWEEP TIME (SEC) pushbutton and adjust the VAR control to desired sweep.

j. For 10 sec to 100 sec sweep, press the 10. SWEEP TIME (SEC) pushbutton and adjust the VAR control to desired sweep.

2-38. SWEEP TRIGGER MODE.

2-39. The TRIGGER mode pushbuttons are enabled when the MANUAL SWEEP control is in OFF position and disabled when MANUAL SWEEP is on. The TRIGGER mode provides four alternate ways to trigger the sweep. Three trigger modes are automatic recurring triggers: Internal (INT), Line (LINE) and External (EXT) trigger mode. The fourth trigger mode (SINGLE) is for manual triggering of a single sweep. For the 10. SWEEP TIME (SEC) setting, the sweep can be returned to start before completion of the sweep by pressing the SINGLE pushbutton a second time. This allows a convenient repositioning of the pen in X-Y recorder operation during long sweep time modes. The function of the automatic recurring sweep triggers are as follows:

a. Internal trigger mode: a free-running sweep selected by the TRIGGER INT pushbutton.

b. Line trigger mode: a line-triggered sweep synchronized at the input power line frequency (50-60 Hz) and selected by the TRIGGER LINE pushbutton.

c. External Trigger mode: an externally-triggered sweep that is triggered by an external trigger pulse input to the TRIG IN connector on the rear panel and selected by the TRIGGER EXT pushbutton.

2-40. Automatic sweep triggering is most convenient for oscilloscope displays. LINE triggering is useful in systems where display or other equipment is line-synchronized; otherwise the INT (Free Run) mode can be used. External triggering can be used for either automatically recurring or one-shot non-recurring sweep synchronized with external equipment. The external trigger pulse (to the rear-panel TRIG IN connector) must be at least +5 V, with a rise time of less than 2 milliseconds. Trigger pulses received during a sweep are disregarded. Any convenient pulse train can trigger or synchronize recurrent sweeps with external equipment if each individual pulse meets the above specifications. For single sweeps, a +5V pulse or step-voltage can be used. Input impedance is 50 kΩ. Single sweeps are convenient for recorder readout, so that a single trace may be triggered after the readout equipment is setup and calibrated. To operate in the TRIGGER modes, proceed as follows:

a. TRIGGER MODE ENABLE. To enable the TRIGGER mode pushbuttons, push the MANUAL SWEEP control in to the OFF position.

b. INTERNAL TRIGGERING. To select the internal triggering mode, press the INT pushbutton and observe that SWEEP indicator lights periodically.

c. LINE TRIGGERING. To select the line triggering mode, press the LINE pushbutton and observe that SWEEP indicator lights periodically.

d. EXTERNAL TRIGGERING. To select the external triggering mode, press the EXT pushbutton and observe that indicator lights. Connect external trigger pulse to EXT TRIG connector (rear panel) and ensure pulse is +5 volts with a rise time of less than 2 msec. Observe that SWEEP indicator lights each time trigger pulse is applied.

NOTE

Sweep output monitoring is available at front panel SWEEP connector. Sweep voltage is dc -coupled sawtooth varying from 0 volts at start to +10 volts at end of sweep, regardless of sweep mode, width, or direction. In clockwise mode, voltage varies from 0 to +10 volts in proportion to Fo and Fo FINE frequency setting. In Manual Sweep mode, voltage varies from 0 to +10 volts, with the position of the Manual Sweep control knob.

2–41. MANUAL SWEEP.

2-42. In Manual Sweep, the RF output frequency can be swept (or tuned) over all or any portion of the full frequency range of the plug-in unit, as determined by the frequency controls and the sweep mode selected; full band, marker or ΔF modes. Frequency is manually controlled by the MANUAL SWEEP knob. Frequency can be swept in either direction, at any desired rate. The limits of frequency change are set by the RF Switches to Full Band, M1→ M2, or ΔF. Markers do appear, if selected. Levelling is available as for normal sweeping operation.

2-43. To monitor specific frequencies in manual sweep, use one or more of the markers, exactly as in the automatic sweep modes. Another way of determining the manual sweep mode output frequency is to turn the MANUAL SWEEP control fully clockwise, and then switch to the Marker Sweep mode (depress the M1 → M2 pushbutton). The manual output frequency is then controlled by the M2 control. Conversely, in the counterclockwise position, it is controlled by the M1 control.

2-44. Both the SWEEP and the voltage-proportional-to-frequency outputs operate normally in this mode. The SWEEP output voltage is especially convenient with X-Y recorders, for precise frequency positioning with the same horizontal axis calibration as for automatic sweep.

2-45. RF blanking is disabled in manual sweep, and the sweep time and triggering controls are disabled, but the markers, modulation, and auxiliary dc sweep output are available.

2-46. To operate the manual sweep, simply pull the MANUAL SWEEP control out until its switch clicks. This automatically disables ALL trigger and sweep time functions.

NOTE

For normal automatic sweep operation, the MANUAL SWEEP control MUST be pushed back in, to enable the Trigger circuits.

2–47. RF MODULATION.

2-48. The RF pushbuttons permit selection of four ways to modulate the RF continuous wave output. The RF can be modulated by the markers, the internal square-wave generator or by an externally-applied square wave input. Blanking of the RF output during retrace is also available. Refer to Paragraph 2-21 for instruction on observing the RF output with an oscilloscope. Frequency modulation is available, using an external modulation signal. With the Modulation Switch set on External, 0 to +10 volts into the FM Input Jack will cause the output frequency to vary from minimum chosen frequency to maximum chosen frequency, Full Band, M1 → M2, or ΔF, determined by the front panel switches. Operation is like that for the Manual Sweep control, but from an external source.

2–49. RF MARKERS.

2-50. The MARKER pushbutton initiates marker generation, which modulates the RF output at the marker frequencies. The markers appear as pips on the RF output and as video triangles at the MARKER output. The markers are useful in spectrum displays for identifying frequencies over the band. The video triangles are useful for oscilloscope and recorder monitoring. The video marker is a -5.0 V ± 0.5 V peak triangle whose amplitude is adjustable from 0 volts to peak voltage by the MARKER AMPL control. In the OFF position, the marker amplitude is reduced to zero volts. For constant RF output in clockwise mode, the MARKER pushbutton should be pressed to OFF.

NOTE

The video markers at the MARKER output connector are not controlled by the RF MARKER pushbutton and are present during all sweep modes. They are only controlled by the MARKER AMPL control.

2-51. To operate in the marker mode, proceed as follows:

a. Set the markers to desired frequency setting.

b. Press the MARKER pushbutton. Observe that indicator lights.

c. Connect oscilloscope to MARKER connector and adjust marker amplitude to desired peak voltage (up to -5 ± 0.5 volts across 1 KΩ). Use MARKER AMPL control for marker amplitude adjustment.

d. To turn off the video and RF markers, turn MARKER AMPL control to OFF position or if it is desired to temporarily remove the RF markers without disturbing the amplitude adjustment, press the RF MARKER pushbutton to OFF.

2–52. INTERNAL SQUARE WAVE RF MODULATION.

2-53. The unit contains a 1 kHz square-wave generator used for modulating the RF output in internal RF modulation mode. The RF continuous wave output is amplitude modulated by the internal 1 kHz square-wave with 50% duty cycle. The modulating frequency is adjustable from 950 to 1050 Hz by the rear panel 1 kHz ADJ control. To operate the internal square-wave modulator, proceed as follows:

a. Set rear panel AM EXT/INT switch to INT position.

b. Press RF AM pushbutton. Observe that indicator lights.

c. If needed, the rear panel 1 kHz ADJ control can be used for varying the square-wave from 950 to 1050 kHz.

2-54. EXTERNAL AMPLITUDE MODULATION.

2-55. The external AM mode permits amplitude modulating the RF output from an external signal source by suitable square or pulse signal (refer to Table 1-1) inputs as follows:

a. Set rear panel AM EXT/INT switch to EXT position.

b. Connect external modulating signal to AM connector at rear panel.

WARNING

To avoid equipment damage, external modulating signals applied to AM connector must not exceed ± 5 volts.

c. Press RF AM pushbutton. Observe that indicator lights.

2-56. RF BLANKING.

2-57. Blanking of the RF signal during retrace is accomplished by pressing the RF BLANKING pushbutton to ON. Observe that indicator lights. Blanking (+) for oscilloscope operation is obtained at +BLANK connector on the rear panel. This blanking is not affected by the RF BLANKING pushbutton.

NOTE

On equipment with serial numbers 75 and above, a -BLANK connector is also provided in addition to the +BLANK connector.

2-58. STABLE CW OPERATION.

2-59. To select continuous wave frequency operation, depress the CW pushbutton, set F_o control to the desired frequency as indicated on the top F_o scale on the dial.

2-60. For precise tuning of a single frequency, there is an F_o FINE frequency adjustment. This F_o FINE control, with its calibrated vernier F_o FINE scale, moves the F_o frequency up or down 0 to 5%. Should you wish to check swept performance, select the FULL BAND, MARKER, or ΔF sweep controls. There is no need to change the position of the F_o indicator.

2-61. PROGRAMMABILITY OF MODEL 6600 SWEEPER MAIN FRAME.

2-62. There are three levels of operation of the Model 6600; manual operation, remote operation through connector J-1, or remote operation through computer interface card (Option 5).

2-63. Level 1: Sweep, CW and Manual Operation.

2-64. The following manual operations have to be performed on the front panel:

a. Select sweep function. The operator has the choice of selecting from five functions:

1) M1 - M2,
2) ΔF around F_o,
3) F_o (CW),
4) F_o FINE (also called F_o V -- F_o vernier),
5) Full band.

2-65. After selecting the sweep function, the operator sets the frequency(ies) on the front panel scale.

a. Select sweep speed: the operator may select from five sweep speeds; 10 sec., 1 sec., 0.1 sec., and 0.01 sec. He furthermore can adjust the sweep speed continuously, using the variable control.

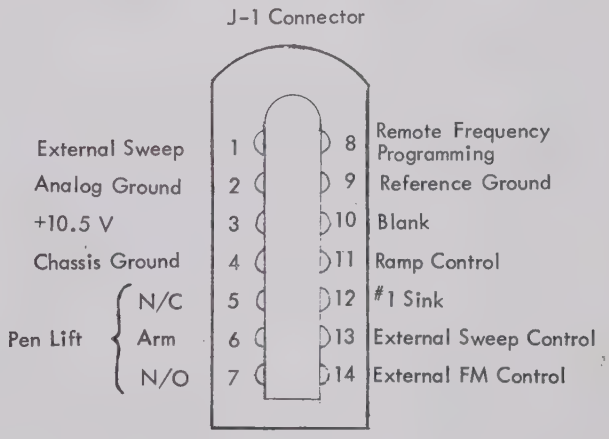
b. Select trigger: the operator has the choice of four different triggers:

1) internal,
2) line,
3) external or single sweep,
4) start of single sweep.

c. RF level manipulations: the operator can select any or all of the three RF manipulations:

1) RF markers (using control to set marker amplitude).
2) AM (this is normally square wave modulated, using back panel mounted switch for internal or external modulation).
3) Blanking.

2-66. Level 2: Remote Operation through Rear Panel Mounted Connector J-1.



2-67. Connector J1 is a 14 pin blue ribbon connector which allows the performance of the following operations remotely:

1) external sweep operation,
2) external FM operation,
3) ramp control,
4) RF manipulations -- (AM, RF markers, RF blanking),
5) pen lift.

2-68. External Sweep Operation.

2-69. When ground pin 13 of J-1 is grounded, all five front panel selectable sweep functions are disabled, the internal ramp generator is turned off, and the sweep input to the oscillator is brought out to pin 1 of J-1, marked EXT SWEEP. A linear 0 - 10V range applied to pin 1 will sweep the oscillator over its full band with the same accuracy, stability, and linearity as under "full band" sweep, provided the external ramp is as good linearly (stability, hum, noise, etc.) as the internal 6600 ramp. The negative lead of the ramp voltage is connected to pin 2 (analog ground). The input voltage to pin 1 does not have to be a 0 - 10V ramp. It can be any signal, for instance, a DC signal placing the sweeper essentially into the F_o (CW) operation. A second input, pin 8 (marked REMOTE FREQUENCY PROGRAMMING), is connected to pin 1 through an internal 250Ω resistor and can be used for frequency corrections, frequency locking, etc. Bandwidth of this control is 50 kHz. This operation can be used to step scan the sweeper remotely by using an external digital to analog (D/A) converter.

2-70. The EXT SWEEP control input is not buffered. To make it computer compatible, buffering and isolation might be necessary.

2-71. External FM Operation.

2-72. When pin 14 of J-1 is grounded, all front panel selectable sweep functions except the F_o function are disabled, and again, the internal ramp generator is turned off, and the sweep input to the oscillator is brought out to pin 1 of J-1. By feeding a signal into pin 1, the oscillator will sweep around the front panel adjusted to point; this operation could be used for frequency modulating the oscillator, as for a narrow sweep around F_o.

2-73. Again, the EXT FM control input is not buffered.

2-74. Ramp Control.

2-75. Grounding pin 11 of J-1 stops the ramp at the voltage which exists at the instant of grounding. This is useful, for instance, if the sweeper is used with a network analyzer which is sweeping slowly and an out-of-spec condition from the item under test is detected. Pin 11 is grounded, stopping the sweep, allowing a precise frequency measurement to be made, using a counter on the sweeper output. As soon as pin 11 is ungrounded, the ramp will continue as before. If the hold time is excessive (longer than 10 msec), the ramp hold voltage will start decreasing slowly due to the leakage current around the ramp generator.

2-76. RF Level Manipulations.

2-77. Pin 12 of J-1 connects to the collector of sink #1.

2-78. Pen Lift.

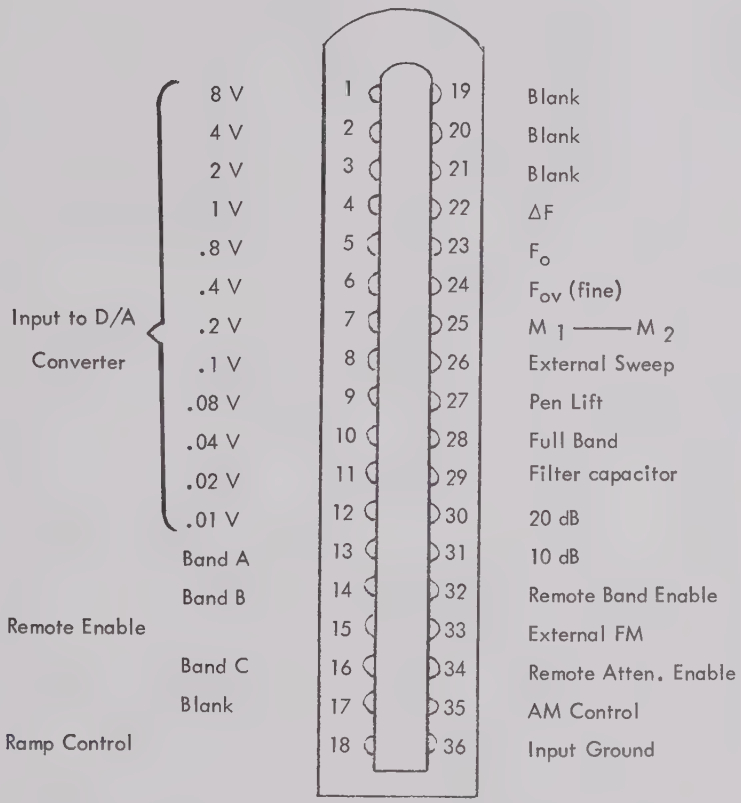
2-79. Pins 5, 6, 7 are used to provide pen lift for X-Y recorders. Pin 6 connects to the arm of a single-pole-double-throw relay-operated switch. Pin 5 connects to the normally closed contact, pin 7 to the normally open contact. The relay is deactivated during sweep, and activated during retrace. Since both contacts are brought out, all pen lift arrangements can be accommodated. Pen lift relay only operates on the 10 sec sweep time.

Level 3: Remote Operation and Digitally Controlled Frequency Programming of Sweeper System through Computer Interface Board (Option 5).

2-81. Drawing D-907547 (see Section VI) is a schematic diagram of the computer interface board which mounts into the upper left corner of the 6600. It contains a 36 pin connector (diagram following) mounted rigidly to this PC board (J8) which forms a remote control input into the 6600. This connector fills out the hole on the back panel of the 6600 in the right upper corner. The markings on the J8 connector already indicate the programmability of the 6600. Complete isolation of control circuits from the circuits of the main frame is provided. The 8-volt supply which is marked +8 volt return and +8 volt in the row of connections at the bottom of the diagram is a totally isolated transformer winding with bridge rectifier and filter. This provides the 5 volts required by the light emitting diode used to control the internal circuits of the main frame. The 8 volts is dropped to 5 volts by the integrated circuit regulator marked IC 2. When any one of the control wires is connected to the input ground wire externally, current flows through the light emitting diode in the (IS 1 through IS 31) integrated circuit isolators. This allows current to flow in the photo-transistor which in turn drives transistors Q1 through Q31 and clamps the collector of each transistor to ground. Each ground connection for Q1 through Q19 controls a relay on the control board of the main frame so that a function is energized. Transistors Q20 through Q31 control a digital to analog converter which converts the digital ground into positive DC voltages which are summed and fed out as D/A OUT on terminal 12 in the line of terminals at the bottom of the drawing. It will be seen from the indicators at the top of the drawing that the voltages may be as small as 0.01 volts or as large as 8 volts for a single control signal. It is possible to provide over 16 volts output; however, the tuning circuit only uses 0 to 10 volts, so the actual operation of tuning is limited to that amount. It will be seen that the code used is a four-bit decimal code rather than pure binary. The three four-bit groups give a total coverage of 1,000 parts in the code.

2-82. Tuning or scanning is controlled by grounding wires 1 through 12. The Option 5 table gives the voltages which will be applied to the tuning circuits when each one of these wires is grounded. In other words, if a 2 - 4 GHz plug-in is plugged into the 6600, the frequency can be scanned in 1000 steps from 2 to 4 GHz. The digital to analog converter output which is pin 12 of P13 provides, therefore, a minimum voltage step of 10 mV. This voltage is fed through K3 of the A5 control board (see Drawing D-907471) to the F1 input of the oscillator. The accuracy of the D/A converter is .1%. The relationship between the actual RF frequency and the digital input word is, therefore, essentially equal to the frequency accuracy of the plug-in oscillator, which in most cases is ±1%. The frequency stability for a selected digital input word is equal to the frequency stability of the oscillator in the F_o position, which is, in general, 0.03% per °C and at reasonably constant room temperature 0.03% per half hour. The residual FM is slightly higher than the quoted CW operation. CW quieting is not used when the frequency is stepped using a digital input. If residual FM is a problem, grounding at pin 29 connects the filter capacitor.

P8 Computer Interface Connector



To control any function on the J8 connector, that function must be connected to ground (J8, Pin 36). P8, Pin 15, Remote Enable, controls the following pins (i.e., Pin 15 must be returned to ground before any remote functions will activate): Pin #22, 23, 24, 25, 26, 27, 28 and 33.

2-83. Pins 13, 14 and 16 are used for band switching. A plug-in with three oscillators in the 9500 Series Broadband System is available which uses the 9514A Controller plugged into the 6600. Two versions are presently produced, the 9514A which is used in conjunction with the 9515A (100 MHz to 18 GHz Broadband System where the operator can select the following five bands: 100 MHz - 2 GHz, 2 - 8 GHz, 4 - 12 GHz, 8 - 18 GHz and 2 - 18 GHz), and the 9514B which operates with the 9515B covering the frequency range from 2 - 18 GHz in four bands: 2 - 8 GHz, 4 - 12 GHz, 8 - 18 GHz, and 2 - 18 GHz. Using a simple truth table, one can see that with these three inputs on the 6600 computer interface board, one can select up to seven frequency bands if so desired.

2-84. Pin 15 is a REMOTE ENABLE control. Returning it to ground disconnects the following pushbuttons from manual control:

a. M-1, M-2,
b. ΔF sweep around F_o,
c) F_o,
d) F_o FINE,
e) Full band,
f) AM pushbutton.

All these controls are then put on remote operation and can be put into operation by computer control as described below. The REMOTE ENABLE pin return to ground also connects the D/A converter output to the frequency control input of the oscillator being used. This connection, however, is only made if none of the other sweep functions is selected. In other words, in REMOTE ENABLE operation, without any of the other sweep functions F_o, ΔF, M1/M2, F_o FINE, full band, or external sweep being activated, the frequency can be scanned or chosen externally using a three digit BCD parallel input word to select frequencies across the full band of the oscillator used, with a resolution of 1/1000th of the full band. If any of the aforementioned sweep functions are selected, the external frequency control through the D/A converter is disconnected and the frequency or swept

frequency range as indicated on the front panel scale (and controlled by manually setting the front panel control knobs) will be used. As an example, if the computer grounds the REMOTE ENABLE pin and the F_o pin (pin 28), the frequency of the 6600 sweeper will go to the F_o CW frequency as set by the manual adjustment on the front panel of the 6600. This is indicated by the F_o pointer on the 6600 front panel scale. If the computer opens the F_o pin and grounds the M-1/M-2 pin (pin 25), the 6600 will sweep the frequency range between the M-1/M-2 front panel scale indication using the sweep speed as manually selected on the 6600 front panel.

2-85. Pin 17, 19, 20 and 21 are not used. Pin 18 activates the ramp control. This control is identical to the ramp control described in paragraph 3-54. Pin 22 activates the ΔF sweep and the sweeper will sweep the ΔF range as set with the front panel control. Pin 28 activates the F_o operation, which is the CW operation at the frequency indicated on the front panel scale with the F_o pointer. Pin 25 controls M-1/M-2 sweep operation. Pin 27 controls the pen lift using the relay operated switch inside the 6600 (see paragraph 3-58, Pen Lift).

2-86. Pin 26 controls the EXT SWEEP operation as described in paragraph 3-48.

2-87. Pin 34 is the ATTENUATOR ENABLE input. Grounding it disables the manual operation of the programmable RF attenuators and puts them under remote control. There are three buffered lines going into the plug-in for remote attenuator control (pin 30 and 31). At present no plug-ins with programmable attenuators are sold as catalog items, but as they become available they will be used. Obviously, these lines could be used for any other switching function which had to be done remotely in the plug-in.

2-88. Pin 35 controls whether the sweep oscillator output is CW (AM off) or internal square wave modulated (pin 35 grounded, manual rear panel 6600 switch in INT) or external amplitude modulated (pin 35 grounded, manual rear panel 6600 switch in EXT position and external modulating signal fed into rear-panel-mounted AM jack). This external input can be either used for square wave AM or with some caution for linear AM (sine wave in - sinusoidal envelope modulation). Since the PIN RF modulator is not very linear, the amplitude of the modulating signal and the DC amplitude of the front panel plug-in mounted level control have to be properly chosen.

2-89. OPTION 5.

2-90. Option 5 for the Model 6600 Sweep Generator Main Frame provides facilities for remote control of the Model 6600 through computer or computer-type circuitry. Control functions include selection of F_o or ΔF, or M1, M2 sweep, external sweep, external FM, internal AM, and external AM. Attenuation of the output RF may be selected as 10 dB, 20 dB. If F_o is chosen for a CW operation, the frequency may be chosen externally using a binary system to select frequencies across the full band in steps of 1/1000th of the band. Circuit operation is described in paragraph 4-129.

2-91. Mounting Computer Interface Board.

2-92. The Computer Interface Kit contains:

1 - Interface Board
1 - Rear Panel Connector Shell
4 - Offset Standoffs
4 - Roundhead Screws to fit tops of Standoffs
4 - Flathead Screws
4 - Lock Washers for Flathead Screws
4 - Nuts for Flathead Screws
2 - Lock Washers for Roundhead Screws

2-93. To mount the Interface Board,

1. Check 6600 Manual for details, if needed, of Cover and Plug-in removal.
2. Remove from the 6600 any Plug-in Unit which is mounted through the front panel.
3. Remove the Top Cover of the 6600.
4. Loosely mount the Offset Standoffs above the four holes in the top of the Plug-in Compartment. Use one Flathead Screw, one Lock Washer, and one Nut for each Standoff. Screws must be inserted from within the Plug-in Compartment.
5. Remove Cover Plate from J8 position on the Back Panel.
6. Lay Interface Board on Standoffs so that the PCB Socket is near the existing PCB Plug and so that the PCB Plug of the Interface Board extends through the J8 hole in the Back Panel.
7. Adjust Standoffs and insert screws into them through the Interface Board.
8. Plug the Interface Board PCB Socket onto the 6600 PCB Plug. Seat firmly, adjust Standoffs as required.
9. Tighten screws which hold Interface Board to Standoffs.
10. Tighten nuts which hold Standoffs to 6600. It may be necessary to use offset screwdriver to hold the screws.
11. Use two screws to mount receptacle shell in J8 position. If necessary, loosen Board mounting screws, in order to center the Board PCB Plug in the shell.
12. Check each screw or nut used in this procedure for normal tightness.
13. Replace Plug-in.
14. Unit is ready for Computer Operation.

Table 2-7. Option 5

TUNING		CONTROLS		CONTROLS	
TERMINAL	VOLTAGE	TERMINAL	FUNCTION	TERMINAL	FUNCTION
1	8V	13	Band A	25	M1 - M2
2	4V	14	Band B	26	Ext. Sweep
3	2V	15	Remote Enable	27	Pen Lift
4	1V	16	Band C	28	Full Band
5	.8V	17		29	Filter relay
6	.4V	18	Ramp Control	30	20 dB
7	.2V	19		31	10 dB
8	.1V	20		32	Remote Band Enable
9	.08V	21		33	Ext. FM
10	.04V	22	ΔF	34	Remote Attn, Enable
11	.02V	23	F_o	35	AM
12	.01V	24	F_oV	36	Input GND

SECTION III
THEORY OF OPERATION

3–1. GENERAL.

3-2. The Model 6600 Main Frame is the control and mounting fixture for a series of RF oscillators. The total system supplies sweep frequencies, constant frequency signals, and modulated signals in the range of the particular plug-in which is used. Power required by the Model 6600 is either 115 volts or 230 volts, 50 - 60 Hz. Power for the Plug-in is supplied by the Model 6600. There is a wide range of sweep rates and there are multiple trigger options as are described later and more particularly in Section II. Within this section there are detailed descriptions of the circuits which are used in the Model 6600 and their operating principles.

3–3. BLOCK DIAGRAM DESCRIPTION.

3-4. Figure 3-1 illustrates the Main Frame in simplified form, showing signal flow only, without regard to the power supplies. Power distribution is shown in Figure 3-2. Figure 3-3 is a block diagram of the ramp generator.

3–5. SIGNAL BLOCK DIAGRAM, FIGURE 3–1.

3-6. The signal block diagram shows signal flow and flow of control voltages used in controlling the output of the Plug-in Unit. The basic signal produced by the Model 6600 Main Frame is the positive tuning ramp which goes from 0 to +10.5 volts. This is the basic voltage sweep which is used to produce the tuning sweeps which may be positive or negative and may be from +9.6 to -9.6 volts or may be a small fraction of that. The timing of the tuning ramp is set by panel controls which select the trigger and the sweep time. The control board A5 contains a number of relays and a diode matrix with which the relays are controlled by remote and local switches. The relays control the routing of amplitude modulation, frequency modulation signals, and which modulation is applied and which sweep may be applied. Modulation inputs are from external jacks; however, on the modulation board there is an internal amplitude modulation square-wave generator. The modulation board supplies to the Plug-in Unit amplitude modulation which controls the gain of the RF amplifier in the Plug-in Unit and the negative voltage ramp which tunes the voltage controlled oscillator in the Plug-in Unit. Operation of the circuits on the various boards is briefly described in the following paragraphs. Detailed circuit descriptions appear in Section IV.

3–7. POWER DISTRIBUTION, FIGURE 3–2.

3-8. Power distribution is shown in Figure 3-2. The voltages supplied by Power Supply A1, Regulator #1, A2, and Regulator #2, A3, are shown routed to the units which they supply. Descriptions of the A1, A2, and A3 modules appear in Section IV.

3–9. DETAIL SIGNAL BLOCK DIAGRAMS.

3–10. RAMP GENERATOR BLOCK DIAGRAM, FIGURE 3–3.

3-11. The basic circuit of the Ramp Generator is the ramp integrator. The sweep timing switches control the amount of current which is fed into the integrator, hence the rate of rise of voltage is controlled. The switch control logic circuits

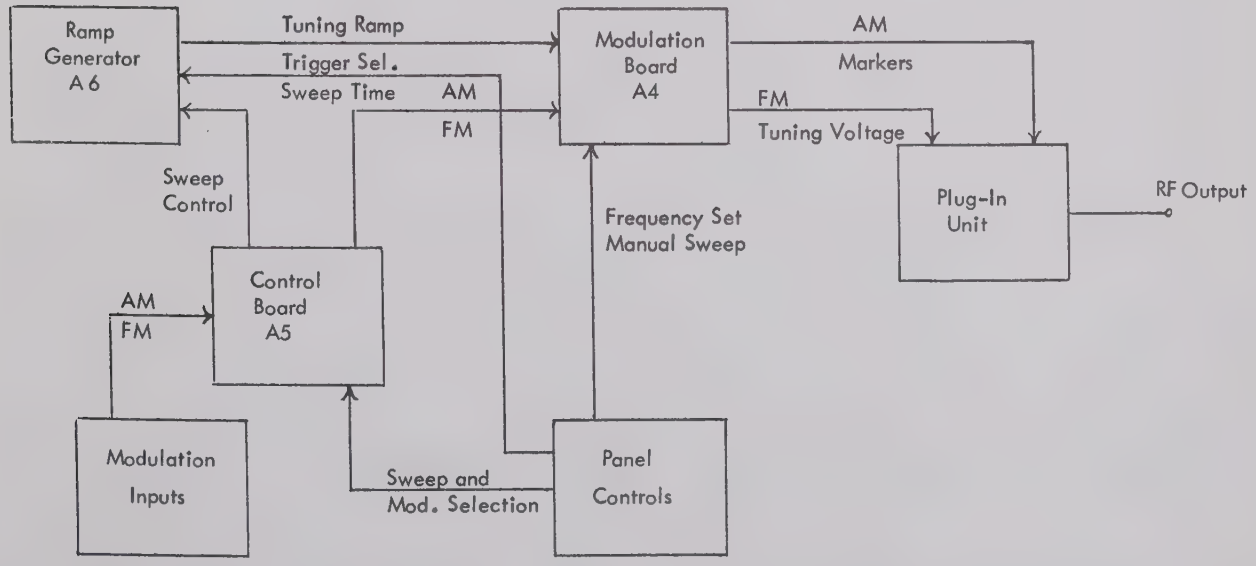


FIGURE 3-1. SIGNAL BLOCK DIAGRAM

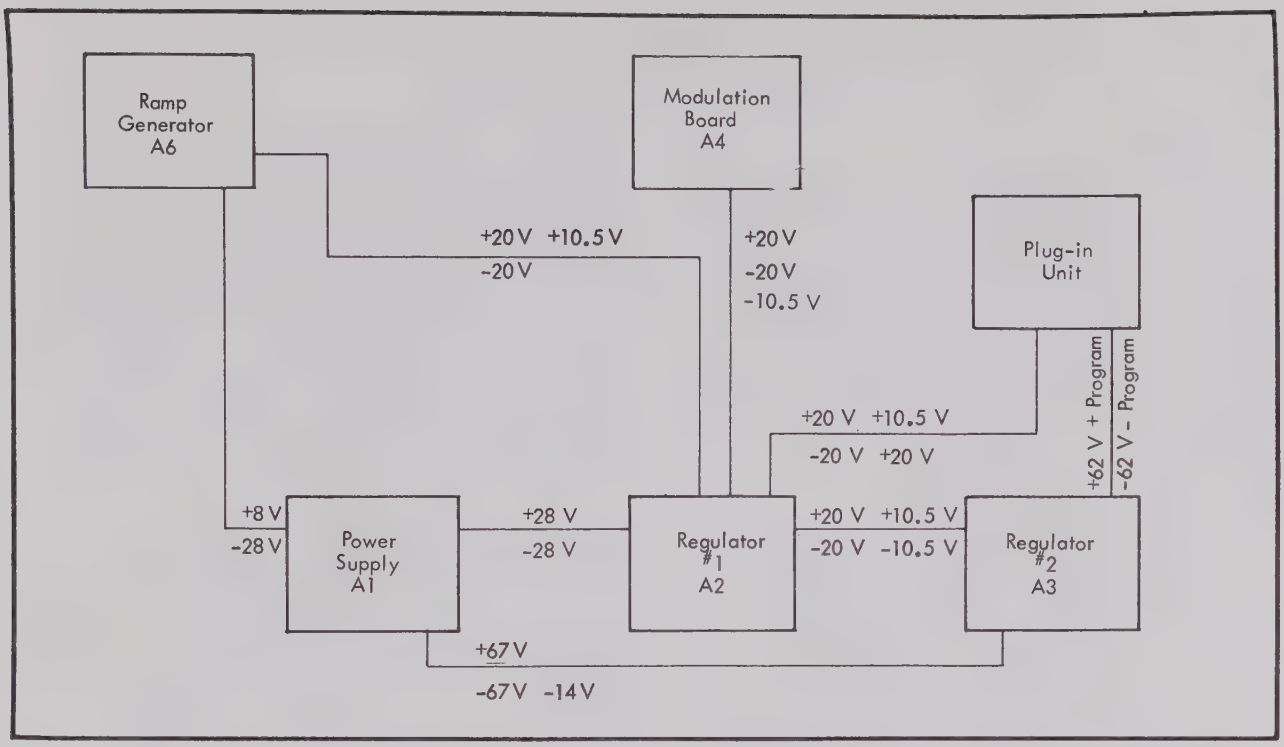


Figure 3-2. Power Distribution Diagram.

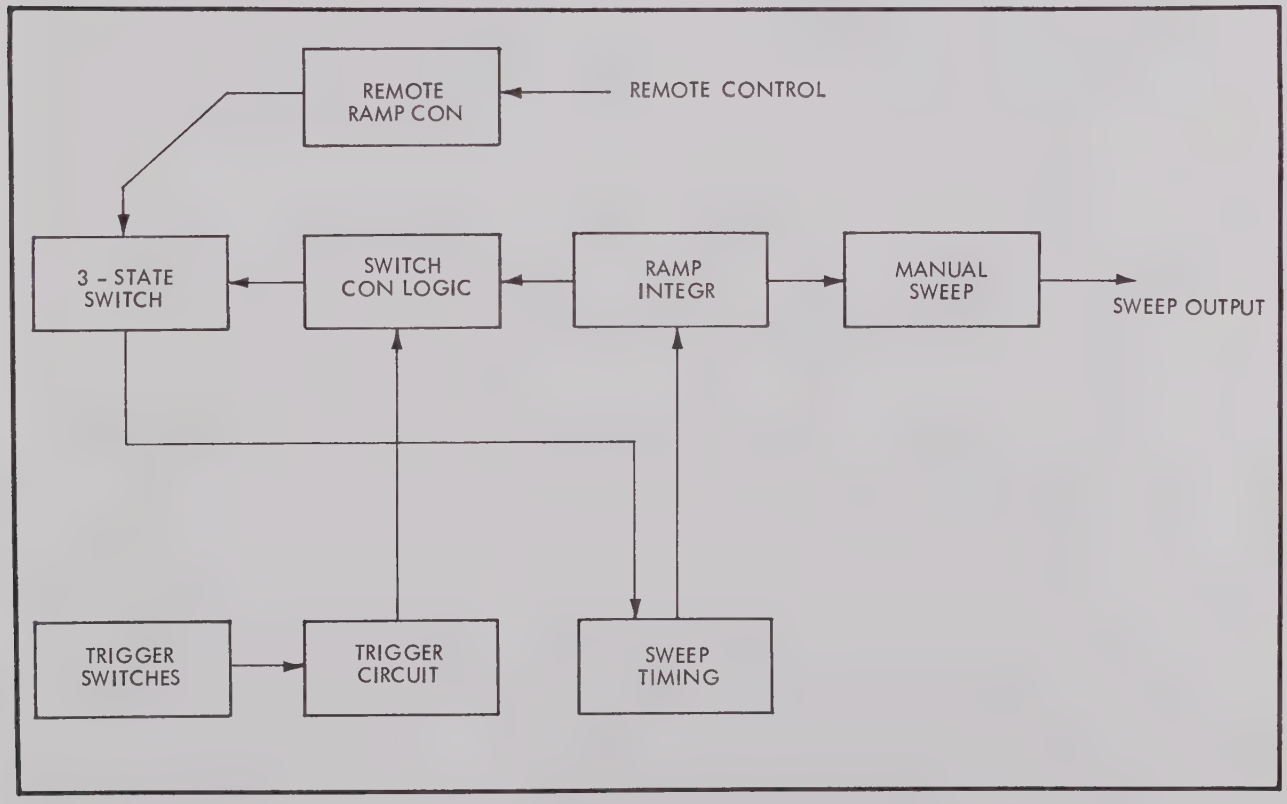


Figure 3-3. Ramp Generator Diagram.

limit the amplitude of voltage sweep, both up, in sweep, and down, in retrace. The three-state switch determines whether the ramp voltage increases at the chosen rate, decreases at the chosen rate, in retrace, or stays at zero. The trigger switches and circuit provide triggers to start the ramp voltage sweep after it has returned to zero. Internal, External, and Line triggers may be used. A single sweep operation is also provided when the single sweep button is pushed. Remote control stops operation of the Ramp Generator when the FUNCTION switch is set on F_o. Operation of the Ramp Generator is also stopped when the Manual Sweep control is pulled to ON position. The Sweep Output is then a stable voltage controlled by position of the Manual Sweep control. A functional schematic diagram of the Ramp Generator is shown as Figure 3-3. Details of Ramp Generator operation follow paragraph 4-92. A schematic showing all parts on Board A6 appears in Section VI.

3–12. MODULATION BOARD BLOCK DIAGRAM, FIGURE 3–4.

3-13. The Modulation Board (A4) generates markers which correspond in time to the times when the swept frequencies match the frequencies selected by M1, M2, and F_o controls. The markers appear as increases in amplitude of the RF output power and as negative pulses at the MARKER output jack. Amplitudes of RF and video pulses are adjustable. A detail schematic of the Marker Generator is Figure 4-11.

3-14. The Modulation Board generates a square wave, adjustable from 950 to 1050 Hz. The square wave amplitude modulates the RF output when selected by panel controls. A detail schematic of the Square Wave Generator is Figure 4-16.

3-15. The Modulation Board also provides amplification and control of external amplitude modulation signals. This circuit also appears in Figure 4-16.

3-16. The Down Ramp amplifier and the ΔF ramp amplifier are on the Modulation Board. They convert the Up Ramp to a Down Ramp, from +10 to 0 volts, and to the ΔF ramp, from -10 to +10 volts.

3-17. The VPF Down Ramp Summing Amplifier, on the Modulation Board, converts the Full Band Up Ramp (0 to +10 volts) into a Down Ramp from +9.6 volts to-9.6 volts. This is supplied as a tuning voltage to some plug-ins. When other than Full Band sweep is selected, the VPF Down Ramp Summing Amplifier converts 0 to +10 volt tuning potentials to corresponding tuning potentials between +9.6 volts and -9.6 volts. A detail schematic of the VPF Down Ramp Summing Amplifier appears in Figure 4-10 (Tuning Voltage Controls).

3-18. The schematic for the entire Modulation Board (A4) is in Section VI.

3–19. GENERAL CIRCUIT THEORY.

3-20. Table 3-1 describes semiconductor circuits which are used repeatedly in Singer instruments.

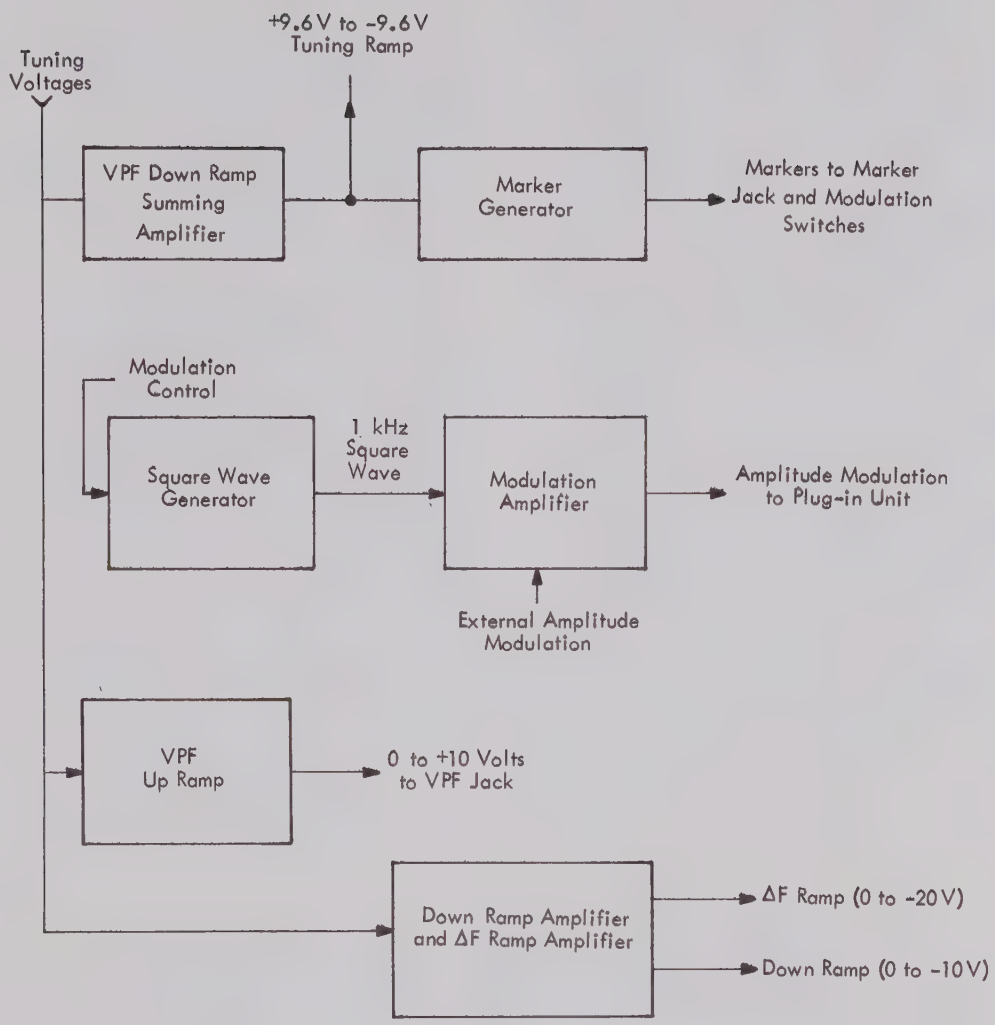


Figure 3-4. Modulation Board (A4) Block Diagram

TABLE 3-1. GENERAL CIRCUIT THEORY.

1. Singer Instruments are formed, principally, of standard semiconductor circuits which are in common use. A few special circuits are used repeatedly. These two classes of circuits are described in detail immediately hereafter. Some special circuits are used once or twice only. These circuits are described in detail, in Section 4 as the detailed circuit description, in order of signal flow, reach those particular circuits.

2. STANDARD CIRCUITS.

3. The circuits in Figure 1 use PNP (circuitA) and NPN (circuit B) transistors to convert low-level low-impedance signals to high-level high-impedance signals at higher levels of power. Signals into the input of each circuit cause current to flow in the input resistors. As the input voltage goes

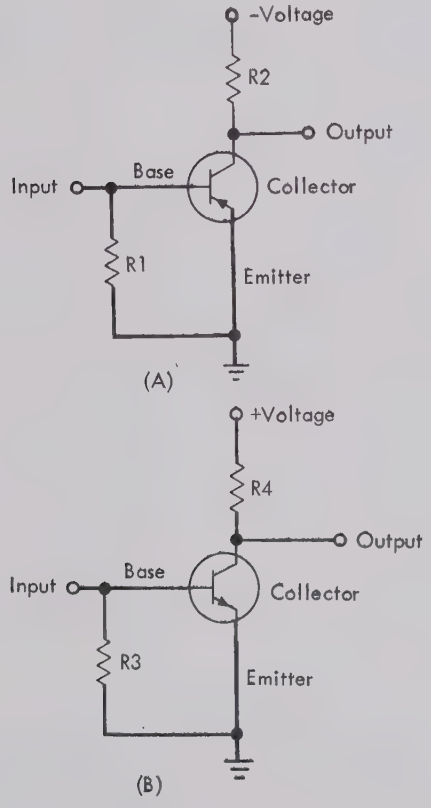


Figure 1. Common Emitter Amplifiers

negative (A) or positive (B), current flows in the base of the transistor. This allows current to flow between collector and emitter, in an amount equal to B times the base current. The collector current causes voltage drop across the collector resistor. The collector offers high impedance to current flow (a large change in collector-emitter voltage causes only a small change in collector current). Hence

$$E_C = B\, i_b\, R_C$$

Where E_C = Voltage across Collector Resistor, R_C

B = Current Gain of Transistor

i_b = Current in Base of Transistor

For low impedance into the base (usually around 1 kΩ) and high impedance at the collector, possible power gain is usually 25 dB to 40 dB or more. Polarity of the voltage changes are, of course, reversed from base to collector. These circuits will be called common emitter amplifiers.

4. The two circuits in Figure 2 use PNP (circuit A) and NPN (circuit B) transistors to convert medium-to-high level medium-impedance signals to medium-to-high level low-impedance signals at higher levels of power. The base of

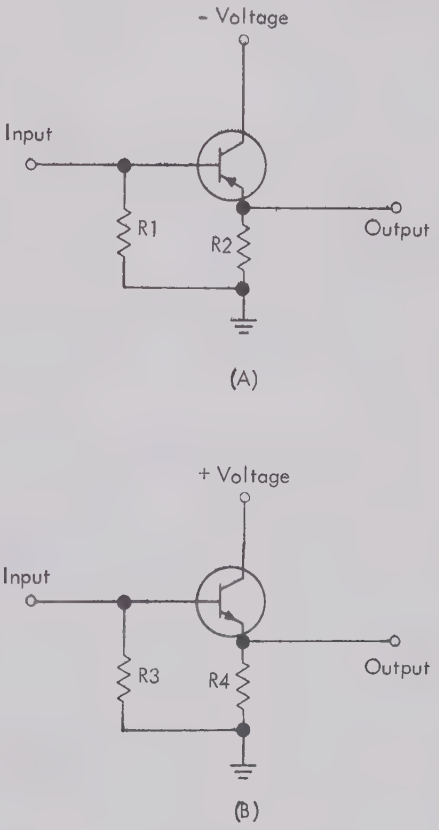


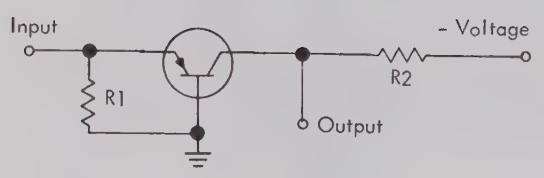
Figure 2. Emitter-Follower Amplifiers

of each transistor offers an impedance-to-input of B times the emitter resistor value, plus approximately 1 kΩ. Current in the emitter is equal to the base current times (B+1), the B representing collector current, the "1" representing base current. Impedance level of the emitter is equal to impedance of the circuit driving the input divided by (B+1).

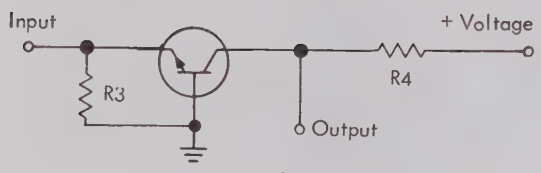
5. In this circuit there is a slight loss of voltage variation, from input to output. Possible power gain is usually from 20 dB to 30 dB. These circuits will be called emitter followers.

6. The two circuits in Figure 3 use PNP (circuit A) and NPN (circuit B) transistors to convert currents from a low impedance source to currents of almost the same value into a high impedance load.

TABLE 3-1. GENERAL CIRCUIT THEORY (CONTINUED)



(A)



(B)

Figure 3. Common Base Amplifier

Current in the emitter of either transistor splits between the base and the collector. The relation is the same as before.

$$I_c = B\, i_b$$

$$I_e = (B+1)\, i_b$$

Since the collector impedance is high, the load impedance can be high. Power out is equal to $I\ R_{out}$. Emitter impedance is low (approximately $1\ \Omega \div [B+1]$). Power in is equal to $I_e^2\, R_{in}$.

7. Power Gain G_p is:

$$G_p = \frac{I_c^2\, R_{out}}{I_e^2\, R_{in}}$$

$$= \frac{(Bi_b)^2\, R_{out}}{[(B+1)\, i_b]^2\, \frac{1\ k\Omega}{(B+1)}}$$

$$= \frac{(B+1)(Bi_b)^2\, R_{out}}{(B+1)^2\, i_b^2 \cdot 1\ k\Omega}$$

$$= \frac{B^2\, R_{out}}{(B+1)\, 1\ k\Omega}$$

Since B+1 is only slightly larger than B, assuming B = 50 or more, which is common,

$$G_p \approx \frac{R_{out} \cdot B}{1\ k\Omega}$$

Since the collector impedance is generally from 20 k Ω to 100 k Ω,

$$G_p \approx \frac{60\ k\Omega \cdot B}{1\ k\Omega} = 3{,}000 = 35\ dB$$

Usual power gain is 10 dB to 20 dB. This circuit is usually used to obtain higher frequency response in an amplifier. It will be called a common base amplifier.

8. TWO-STAGE AMPLIFIERS.

9. The circuits described in this section contain two stages of amplification, using the circuits described in Section 2. Circuits may be direct coupled, capacitor coupled, or transformer coupled.

10. The circuit in Figure 4 has in it two common emitter circuits, capacitor coupled.

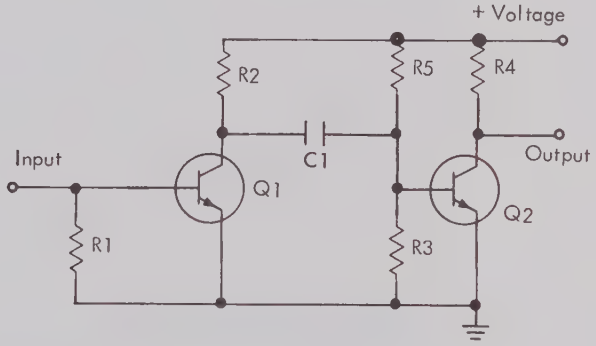


Figure 4. Two-Stage Capacitor-Coupled Amplifier

Resistor R5 is added to provide bias to Q2 so that Q2 will not normally be cut off. R3 is often not used in the circuit, since it puts additional load on the output of Q1.

11. Another bias variation connects the top of R5 to the output rather than to + voltage. Since output voltage changes are of opposite polarity to input voltage changes, this is a negative feedback path which tends to maintain constant collector current in Q2. This gives automatic bias correction for changes in supply voltage and in temperature. Input impedance to Q2 is lowered, which reduces overall gain, generally by about 3 dB. Capacitor C1 disconnects the direct voltage of the Q1 collector from the base of Q2 so that the biasing described above may be achieved. This circuit will be called a two-stage capacitor coupled cascade amplifier.

12. The circuit, as shown, has a power gain, usually, of 40 dB to 60 dB. The loss of gain below twice that shown for each simple amplifier is due to the low impedance (1 k Ω) load presented to the collector of Q1 by the base of Q2.

TABLE 3-1. GENERAL CIRCUIT THEORY (CONTINUED)

13. The circuit in Figure 5 uses one PNP (Q1) and one NPN (Q2) transistor in a two-stage direct coupled amplifier.

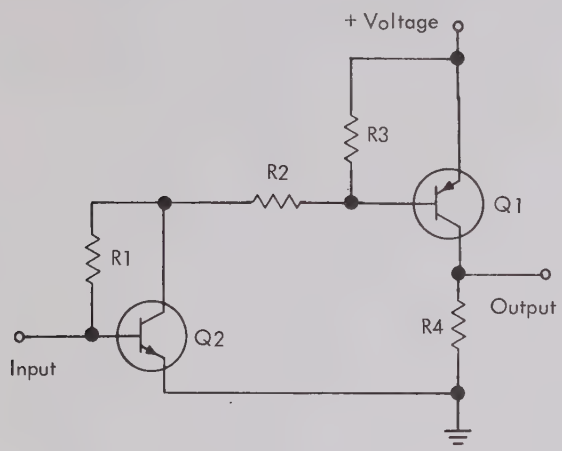


Figure 5. Two-Stage Direct-Coupled Amplifier

The input current varies the current to the base of Q2. Current is normally supplied through R1, which maintains a constant current in the collector of Q2. This feedback current, however, is not sufficient to cancel the effect of the input current. For this automatic bias circuit, the collector current change is about 70% of what it would be if fixed bias was provided. R2 provides voltage changes at the collector of Q2 so that automatic bias in R3 bypasses part of the collector current from Q2 so that it does not go to the base of Q1. Since current into the base of Q1 varies as the square of the voltage across R3, R3 can be selected so that more than half the collector current of Q2 flows through R3, but more than 70% of the changes in the collector current of Q2 occur in the base current of Q1.

14. Changes in the collector current of Q1 are equal to B times changes in base current. The current gain through the whole circuit:

$$G_I \approx B_2 \cdot 0.7 \cdot 0.7 \cdot B_1$$

$$= 0.5\, B_1 B_2$$

Input impedance to Q2 is about 800Ω, considering effect of feedback. Assuming a 1 kΩ load, R4 power gain is:

$$G_p = (0.5\, B_1 B_2)^2 \frac{1\,k\Omega}{800\,k\Omega} =$$

For $B_1 = B_2 = 60$,

$$G_p = (0.5 \cdot 60 \cdot 60)^2\, 25 = 4{,}050{,}000 = 66\ dB$$

This is a common figure for the power gain of this type of circuit. This circuit will be called a complementary two-stage amplifier.

15. The circuit shown in Figure 6 uses two NPN transistors in common emitter configuration, transformer coupled. DC bias for Q1 is provided by R1 and R2. R5 determines the emitter-current flow for the voltage set by R1 and R2. Direct collector current is usually set at one-half the desired peak current. R3 and R4 provide bias for Q2. R6 determines emitter current flow for Q2. Capacitors C2 and C3 bypass

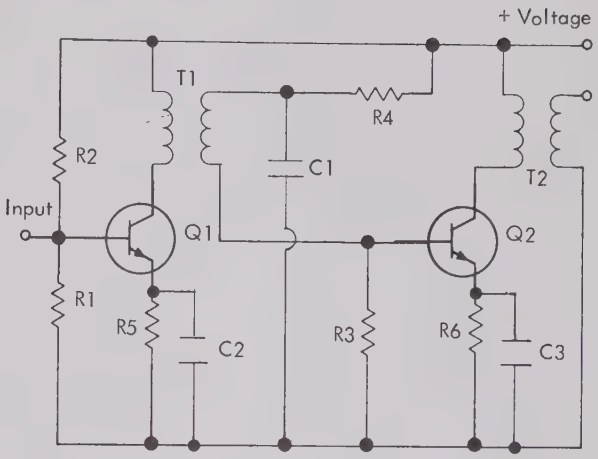


Figure 6. Two-Stage Transformer-Coupled Amplifier

around the emitter resistors so that input impedance (ac) to the transistors is low, hence low power is needed to provide the proper signal current into each base. In each transistor, input signal current times B is equal to collector signal current.

16. The transformer, T1, matches impedance of the collector of Q1 (around 16 kΩ) to the impedance of the base of Q2 (around 1 kΩ). This makes signals current into the base of Q2 four times the collector signal current in Q1. C1 bypasses transformer current to ground so that the load on the transformer is actually 1 kΩ, rather than 1 kΩ plus R4, which is what it would be without C1.

17. From the preceding discussion it is seen that current in the primary of T2 will be:

$$I_{T2} = I_{input}\, B_1 \cdot 4 \cdot B_2$$

For $B_1 = B_2 = 60$,

Current Gain $G_I = 60 \cdot 4 \cdot 60 = 14{,}400$

Assuming 1 kΩ input impedance and 16K impedance at the T2 primary, Power Gain:

$$= G_I^2 \cdot \frac{Z_{out}}{Z_{in}}$$

$$= 14{,}400^2\ \frac{16K}{1K}$$

$$G_p = 207{,}360{,}000 \times 16 = 3{,}717{,}760{,}000$$

$$\approx 96\ dB$$

The secondary of T2 is to be connected to the load. The turns ratio of T2 is to be the ratio required for exact impedance match. It will be seen that insertion of transformers increases the gain of the two-stage complementary amplifier by 30 dB. This is done at the expense of inserting a number of biasing resistors and bypass capacitors, and of eliminating direct current amplification.

TABLE 3-1. GENERAL CIRCUIT THEORY (CONTINUED)

NOTE

Descriptions of multi-transistor amplifiers will be in the general form: For example, "Three-stage, capacitor coupled, plus complementary two-stage, plus emitter follower, amplifier." This means 3 stages of Figure 1A (or B), capacitor coupled as in Figure 4, followed by the circuit of Figure 2A (or B).

18. INTEGRATED CIRCUITS.

19. Several types of integrated circuits are used. They will be treated as single active parts having one or more inputs and one or more outputs. For signal tracing purposes, power supply connections will be ignored except where they are used as signal outputs. These applications will be described in detail in the Circuit Theory text.

20. OPERATIONAL AMPLIFIERS.

a. Operational amplifiers are direct-coupled multi-transistor amplifiers. They have differential inputs and either single or differential output current and/or voltage gain is usually from 1,000 to 100,000. Power gain is not especially high because input impedance is usually very high (1 MΩ or more), and output impedance is rather low (about 500 Ω). Assuming:

current gain = G_I = 100,000

input impedances = Z_{in} = 1 MΩ

output impedance = Z_{out} = 500 Ω

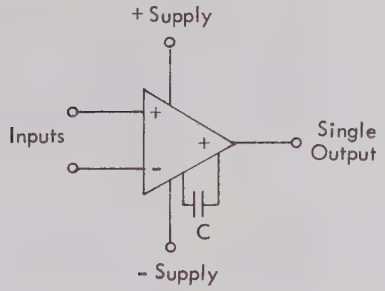
$$\text{Power Gain} = G_p = G_I^2 \frac{Z_{out}}{Z_{in}}$$

$$= (10^5)^2 \frac{500\,\Omega}{10^6\,\Omega}$$

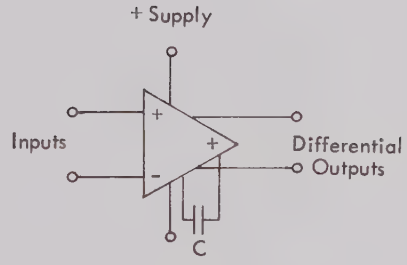
$$G_p = 5 \cdot 10^6 = 67 \text{ dB}$$

This is similar to the gain of a two-stage complementary amplifier.

21. The characteristics which lead to the use of IC operational amplifiers are very high impedance inputs, high rejection of effect of common mode inputs (both differential inputs move in the same direction, over many volts, while the differential voltage only moves a few millivolts), and low phase shift through the circuits so that negative feedback can be used readily without causing oscillations. The symbols used are shown in Figure 7, A and B. In Figure 7A and B, capacitor C is a frequency compensation capacitor, usually having a value of 10 to 100 pF. This capacitor reduces probability of oscillation. It the voltage on the input marked + is more positive than the voltage on the input marked -, output voltage from the terminal marked + is positive with respect to the center point of + supply and - supply voltages. A negative voltage on + input (in the terms used previously) gives a negative output voltage. The output terminal marked - has opposite polarity to that of the + output terminal. From the aforementioned, it will be seen that a positive voltage on - input will give a negative voltage on + output, and vice versa.



(A)



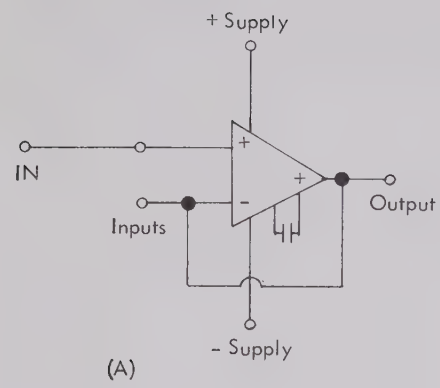
(B)

Figure 7. Operational Amplifiers

22. Operational amplifiers are often used as unity gain amplifiers with very low output impedance. Figure 8A and B show non-inverting and inverting unity gain amplifiers. In Figure 8A, +1 volts above ground (center between + supply and - supply) will drive the output positive. When the output is within a few microvolts of IN, the differential input is only a few microvolts, but this is sufficient to hold the output to +1 volt. The difference between input (IN) and output is approximately IN voltage divided by 100,000 (Gain).

23. In Figure 8B, +1 volts above ground (center between + supply and - supply) will drive the output negative. If the resistance of R1 is exactly equal to the resistance of R2, the potential at the minus input will be zero when output voltage is -1 volts. For output to be -1 volts, - input must be +1 volts divided by 100,000. Output voltage is of opposite polarity to input. The difference between output voltage magnitude and IN voltage magnitude is approximately IN voltage divided by 50,000.

TABLE 3-1. GENERAL CIRCUIT THEORY (CONTINUED)



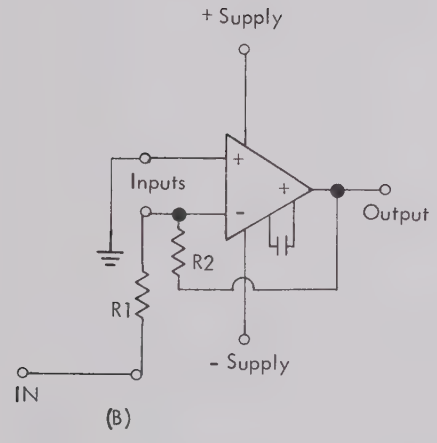


Figure 8. Unity Gain Operational Amplifiers

24. Operational amplifiers are often used as high gain linear amplifiers. In Figure 8B, if the resistance of R2 is 100 times the resistance of R1, the output voltage will be approximately 100 times IN voltage but of opposite polarity. This makes - input zero. For unity gain, here is a drop of one part in 50,000 in the output voltage so that - input voltage will have the valued required to produce the output voltage. This circuit cancels noise due to supply voltage variations; hence it is often used where high fidelity amplification is required.

25. Operational amplifiers are used as integrators. A typical simple circuit is shown in Figure 9. A positive voltage at IN will cause current to flow in R. This raises the voltage at the - input, so the output voltage goes negative, which, via C2, holds the - input voltage at approximately zero. Current through R must, effectively, flow into C2, hence it must also flow out of C2, into the amplifier output. This means that the voltage across C2 increases with time. Since - input voltage is very near ground potential and very near constant, in terms of the voltages usually applied at IN, the current through R is directly proportional to voltage at IN. The voltage across C2 is the exact time integral of the voltage at IN.

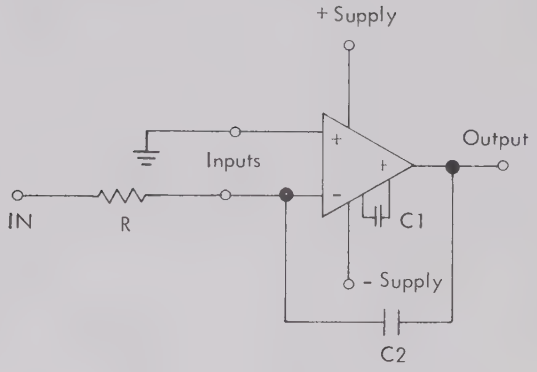


Figure 9. Integrating Operational Amplifiers

26. This circuit is used to produce the integral of a varying voltage, but it is usually used to produce voltage ramps which are linear with time. If the voltage at IN is constant, the output voltage is a linear voltage ramp until a limit of output voltage is reached.

27. Operational amplifiers are used as limit detectors (Figure 10). A differential input of a few microvolts will cause the output voltage of the amplifier to go to one limit. A similar magnitude of differential input, of opposite polarity, will cause the output voltage to go to the opposite limit. If a reference voltage is applied to one input, and an unknown voltage is applied to the other input, the output voltage will show polarity of voltage differences less than 1 millivolt. If the reference is equal to a limit voltage, the output changes polarity as the unknown voltage reaches and passes the limit voltage. This circuit is often used to control linear voltage ramps.

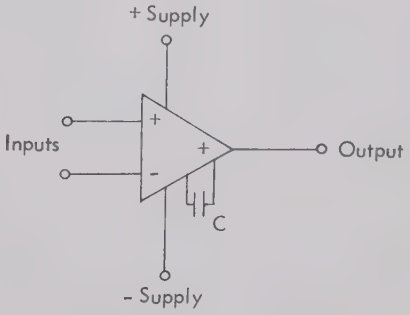


Figure 10. Limit Detector Operational Amplifiers

TABLE 3-1. GENERAL CIRCUIT THEORY (CONTINUED)

28. LOGIC CIRCUITS.

29. The basic logic circuits are AND and OR gates. Symbols are shown in Figure 11. Logic circuits of all kinds usually operate from +5 volt supplies. Power connections are seldom shown in schematic diagrams. Actual signal voltages may vary in magnitude, but the standard signal voltage convention is: Plus 5 Volts is called High (H) or One (1); Zero Volts is called Low (L) or Zero (0). For the symbols shown in Figure 3-14: If both A and B of the AND Gate are 1, output C is 1. If either A or B of the AND Gate is 0, C is 0. If either A or B of the OR Gate is 1, C is 1. If both A and B of the OR Gate are 0, C is 0.

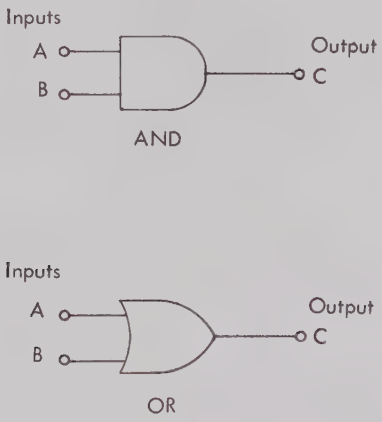


Figure 11. Logic Gate Symbols

30. Figure 12 shows another symbol. A small circle at any signal terminal of a gate reverses the meaning of any signal through the circle. NAND means "Not AND". For A and B both = 1, C is 0 ("Not 1"). NOR means "Not OR". For either A or B = 1, C is 0 ("Not 1"). In the Hybrid OR gate, 0 at A will give 0 at C. 1 at B will give 0 at C. Zero at B and 1 at A will give 1 at C.

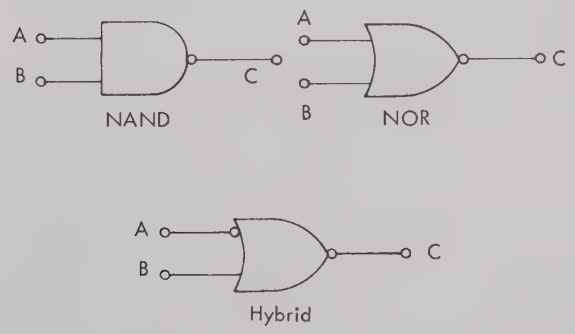


Figure 12. Gate Inversion Symbols

31. Another circuit in common use is the flipflop. This is also called a bistable multivibrator. Figure 13 shows the standard symbol. As with gates, flipflops generally use a +5 volt supply, which is not shown on most schematics.

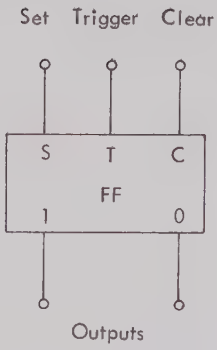


Figure 13. Flipflop

32. The flipflop is a two-state device. If Output 1 is 0, Output 0 is 1. If Output 0 is 0, Output 1 is 1. If there are no signal inputs, the flipflop will maintain its state. A 1 into Set (S) will cause a 1 at Output 1, regardless of past state. A 1 into Clear (C) will cause a 0 at Output 1 (hence a 1 at Output 0) regardless of past state. A 1 pulse into Trigger (T) will reverse the state of the flipflop. The reversal occurs at the leading edge of the pulse. A long pulse (over 5 milliseconds, usually) may cause indeterminate output for some flipflops. Others ignore everything but the positive-going leading edge.

33. Flipflops are used to store logic information in a circuit. This can be contrasted with the immediate transfer of information by amplifiers and by gates.

34. Two circuits of limited use are the other two multivibrators. They are the: (1) free-running MV or oscillator, and (2) monostable MV or one-shot. The free-running MV produces an alternating voltage of approximately square wave form. The one-shot reacts to an incoming 1 pulse by producing a 1 output pulse at a constant time thereafter. Timing of the delay may vary from a fraction of a microsecond to many seconds, or even a few minutes. Usual times are in the millisecond to second range.

TABLE 3-2. TROUBLESHOOTING TRANSISTORS

1. ISOLATING TROUBLE IN TRANSISTOR CIRCUITS.

2. The following procedures and data are given to aid in determining whether a transistor is operational. Tests are given for both in-circuit and out-of-circuit transistors.

3. IN-CIRCUIT TESTING.

4. The common causes of transistor failures are internal short- and open-circuits. In transistor circuit testing the most important consideration is the transistor base-emitter junction. Like the control grid of a vacuum tube, this is the operational control point in the transistor. This junction is essentially a solid state diode. For the transistor to conduct, the diode must conduct; that is, the diode must be forward biased. As with simple diodes, the forward-bias polarity is determined by the materials forming the junction. Use the transistor symbol on the schematic diagram to determine the bias polarity required to forward-bias the base-emitter junction. The A part of Figure 1 shows transistor symbolts with terminals labeled. Notice that the emitter arrow conventionally points toward the type N material. The other two columns of the illustration compare the biasing required to cause conduction and cut-off in transistors and vacuum tubes. If the transistor base-emitter diode (junction) is forward-biased the transistor conducts. If the diode is heavily forward-biased, the transistor saturates. However, if the base-emitter diode is reverse-biased the transistor is cut-off. The voltage drop across a forward-biased emitter-base diode varies with transistor collector current. For example, a germanium transistor has a typical forward-bias, base-emitter voltage of 0.2-0.3 volts when collector current is 10-100 ma. In contrast, forward bias voltage for silicon transistors is about twice that for germanium types: about 0.5-0.6 volts when collector current is low, and about 0.8-0.9 volts when collector current is high.

5. Figure 1, part B, shows simplified versions of the three basic transistor circuits and gives the operating characteristics of each. When examining a transistor stage, first determine if the emitter-base diode is biased for conduction (forward-biased) by measuring the voltage difference between emitter and base. When using an electronic voltmeter, do not measure directly between emitter and base: there may be sufficient loop current between the voltmeter leads to damage the transistor. Instead, measure each voltage separately with respect to a voltage common point (e.g., chassis). If the emitter-base diode is forward-biased, check for amplifier action by short-circuiting base to emitter while observing collector voltage. The short-circuit eliminates base-emitter bias and should cause the transistor to stop conducting (cut off). Collector voltage should then shift to near the supply voltage. Any difference is due to leakage current through the transistor and, in general, the smaller this current, the better the transistor. If collector voltage does not change, the transistor has either an emitter-collector short circuit or emitter-base open circuit.

6. TESTING TRANSISTORS WITH AN OHMMETER.

7. The two common causes of transistor failure are internal short- and open-circuits. Remove the transistor from the circuit and use an ohmmeter to measure internal resistance. See Table 1 for measurement data.

CAUTION

Most ohmmeters can supply enough current or voltage to damage a transistor. Before using an ohmmeter to measure transistor forward or reverse resistance, check open-circuit voltage and short-circuit current output ON THE RANGE TO BE USED. Open-circuit voltage must not exceed 1.5 volts and short-circuit current must be less than 3 ma. See Table 2 for safe resistance ranges for some common ohmmeters.

8. FIELD EFFECT TRANSISTORS (FET)

9. The symbols shown are for simplest construction, non-protected, non-insulated gate FET. Multiple gate and insulated gate FET are also in common use. Operation is similar to operation of vacuum tubes, but both polarities of FET are used. Drain voltages may be in the vacuum tube plate voltage region, but usually are below 50 volts. FET may be saturated or open with zero volts from Gate to source. This depends on construction. Forward voltages on the Gate can seldom cause trouble, but static voltages developed by the technicians clothes may put reverse voltage on the gate sufficient to destroy the FET. For storage and handling the Gate should be shorted to the source. Touch hand, tool, or test probe or clip to the source before touching it to the Gate.

10. To determine whether an FET is in operating condition, leave in the circuit, and apply +1.5V, GND, and -1.5V, in turn, from Gate to Source. Observe change in output voltage. A convenient source of 1.5 volts is your ohmmeter; however an additional meter is required to observe output voltage. DO NOT apply more than 50% of Drain Voltage value as a reverse bias on the Gate. This is a common limit value for noninsulated FET. For non-operating checks of FET, the published static characteristics should be consulted. Variations from one type to another may have ratios of 1,000 or 100,000. Universal tests are not applicable.

TABLE 3-2. TROUBLESHOOTING TRANSISTORS (CONTINUED)

Table 1. Out-of-Circuit Transistor Resistance Measurement

Transistor Type		Connect Ohmmeter: Pos. lead to	Connect Ohmmeter: Neg. lead to	Measure Resistance (ohms) Germanium	Measure Resistance (ohms) Silicon
PNP	Small Signal	emitter	base*	200 - 500	1K - 3K
		emitter	collector	10K - 100 K	very high (might read open)
	Power	emitter	base*	30 - 50	200 - 1000
		emitter	collector	several hundred	high, often greater than 1M
NPN	Small Signal	base	emitter	200 - 500	1K - 3K
		collector	emitter	10K - 100K	very high (might read open)
	Power	base	emitter	30 - 50	200 - 1000
		collector	emitter	several hundred	high, often greater than 1M

* To test for transistor action, add collector-base short. Measured resistance should decrease.

Table 2. Safe Ohmmeter Ranges for Transistor Resistance Measurements

Ohmmeter	Safe Range(s)	Open Ckt Voltage	Short Ckt Current	Lead: Color	Lead: Polarity
H-P 412A	R x 1K	1.0V	1 ma	Red	+
	R x 10K	1.0V	100 μa	Black	-
	R x 100K	1.0V	10 μa		
	R x 1M	1.0V	1 μa		
	R x 10M	1.0V	0.1 μa		
H-P 410C	R x 1K	1.3V	0.57 ma	Red	+
	R x 10K	1.3V	57 μa	Black	-
	R x 100K	1.3V	5.7 μa		
	R x 1M	1.3V	0.5 μa		
	R x 10M	1.3V	0.05 μa		
H-P 410B	R x 100	1.1V	1.1 ma	Black	+
	R x 1K	1.1V	110 μa	Red	-
	R x 10K	1.1V	11 μa		
	R x 100K	1.1V	1.1 μa		
	R x 1M	1.1V	0.11 μa		
Simpson 260	R x 100	1.5V	1 ma	Red	+
				Black	-
Simpson 269	R x 1K	1.5V	0.82 ma	Black	+
				Red	-
Triplett 630	R x 100	1.5V	32 ma	Varies with Serial Number	
	R x 1K	1.5V	3.25 ma		
Triplett 310	R x 10	1.5V	750 μa		
	R x 100	1.5V	75 μa		

TABLE 3-2. TROUBLESHOOTING TRANSISTORS (CONTINUED)

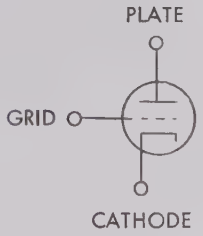
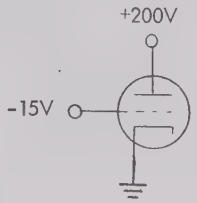
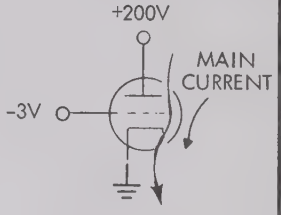
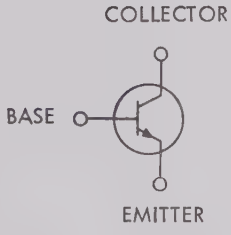
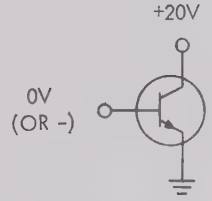
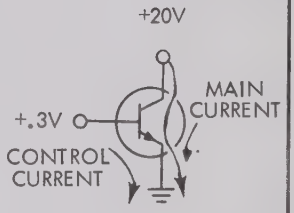
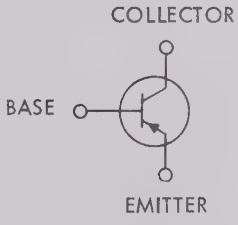
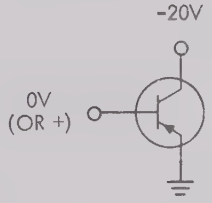
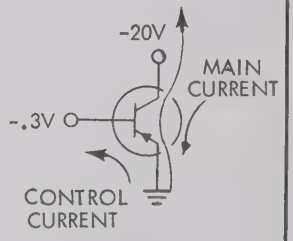
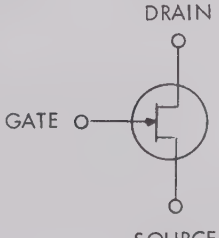
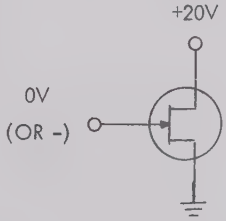
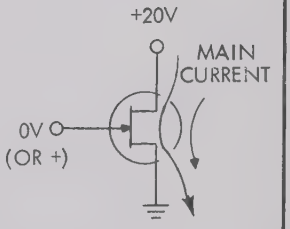
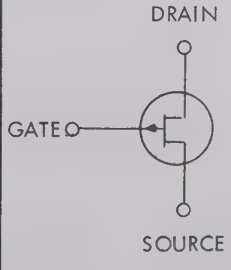
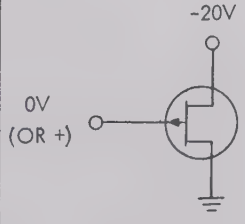
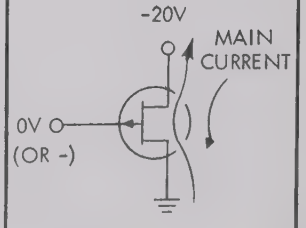
A. TRANSISTOR BIASING			
DEVICE	SYMBOL	CUTOFF	CONDUCTING
VACUUM TUBE			
NPN TRANSISTOR			
PNP TRANSISTOR			
FIELD EFFECT TRANSISTOR N CHANNEL			
FIELD EFFECT TRANSISTOR P CHANNEL			

Figure 1. Transistor Biasing and Operating Characteristics, Page 1 of 2

TABLE 3-2. TROUBLESHOOTING TRANSISTORS (CONTINUED)

B. AMPLIFIER CHARACTERISTICS

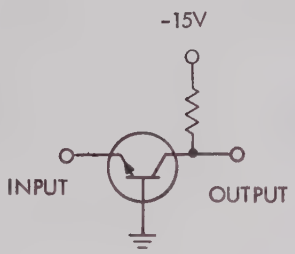
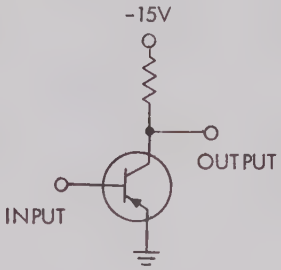
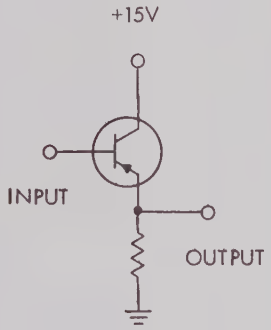
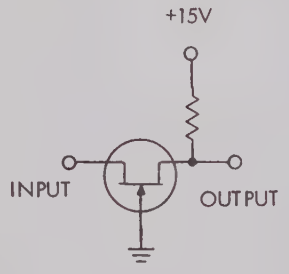
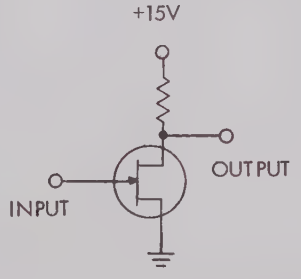
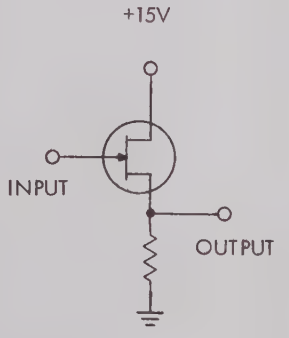
CHARACTERISTIC	COMMON BASE	COMMON EMITTER	COMMON COLLECTOR
INPUT Z	30-50 Ω	500-1500 Ω	20-500K Ω
OUTPUT Z	300-500K Ω	30-50K Ω	50-1000 Ω
VOLTAGE GAIN	500-1500	300-1000	<1
CURRENT GAIN	<1	25-50	25-50
POWER GAIN	20-30 dB	25-40 dB	10-20 dB
			
INPUT Z	1-200 Ω	100K Ω - 10M Ω	100K Ω - 10M Ω
OUTPUT Z	10K-500K Ω	10K-500K Ω	1-200 Ω
VOLTAGE GAIN	50-500K	50-2.5K	<1
POWER GAIN	10K-500K	25K-125 x 10^6	100-2 x 10^6
TRANSCONDUCTANCE = 5K to 10^6 μmhos			
			

Figure 1. Transistor Biasing and Operating Characteristics, Page 2 of 2

SECTION IV
MAINTENANCE

4–1. GENERAL.

4-2. All the procedures in this section should be performed with an operable Plug-in Unit installed in the Main Frame. This is required to provide a full load for the power supply circuits, and to receive a sweep signal from the module. The Plug-in Unit may be connected to the Main Frame by an extender drawer, 952910.

4–3. PRECAUTION.

4-4. The 6600 Main Frame is designed for normal laboratory environments, but it is not seriously affected by wide ranges of temperature. One precaution is necessary, however, in testing of Voltage Regulator Boards. When a Voltage Regulator Board is connected to the Mother Board by an extender card, the series regulator power transistors are no longer touching their heat sinks. Radiation and/or convection heat dissipators must be attached to the transistor mounting plates, and any gaps between plates and dissipators must be filled with thermal conducting paste. Operation for more than five minutes without this provision may destroy one or more power transistors.

4-5. After long-time storage, at temperatures in the vicinity of 75°C or in high-humidity air, the 6600 should be tested for performance (Table 2-6) before it is put into use.

4–6. TROUBLESHOOTING.

4-7. Troubleshooting procedures are described in Table 4-1. They are arranged by circuit functions. To locate the source of trouble for a function which is out of specification, find the function in Table 4-1. The indicated step will describe the proper method to find a faulty part. A Calibration Procedure for the 6600 follows the Troubleshooting Procedures. If adjustments may be required after replacement of parts, the proper step in the Calibration Procedure is given.

4-8. Detailed circuit descriptions follow the troubleshooting chart. Each description is followed by the functional schematic described, with a parts locating diagram, signal flow arrows, voltages and waveforms. Signal Flow is shown as: heavy lines for primary signals, medium lines for secondary signals and dash lines for feedback.

4-9. Troubleshooting steps identify related assemblies, **A1** Figures 4-12. and paragraphs, 4-10. by the types of numbers shown here. Figures are identified, in their lower right corners, by similar numbers.

NOTE

Connections between the functional schematics are shown by references to schematics 4-10.

to which adjacent terminals are connected. Many connections are made through the Mother Board, A4, connectors. Connections between the boards are shown by placing by a connector, the name of the signal and the one or more connector terminals to which it is connected on A4. Where reference is to a part, such as R38, the part is found on page 2, of the A4 schematic, Figure 6-5. Assembly A7 connects the Mother Board A4 to the Plug-in and to the Rear Panel. The connections are shown in Figure 5-4. Connections designated as a supply voltage plus DIS (Distribution) are connected to all others having the same designated voltage. Grounds having the symbol ▽ are all connected to a central point on the board. Similarly, grounds having the symbol ⏚ are all connected to another central point. There is metallic connection on the board between these two points, but circuit ground connections are returned to them separately to help eliminate hum or noise which could be caused by common ground paths.

4–10. COMPONENT LOCATIONS.

4-11. The locations of assemblies within the Main Frame are illustrated in Figure 4-1 thru 4-3. The location of printed circuit boards and test points are shown. To gain access to these components, refer to paragraphs 4-17 through 4-30.

4–12. PARTS LOCATIONS.

4-13. Locations of individual parts are shown with each schematic.

4–14. REMOVING AND INSTALLING PLUG–IN UNITS.

4-15. For removal directions, see Paragraph 2-13.

4-16. For installation directions, see Paragraph 2-15.

4–17. ACCESS TO ASSEMBLY BOARDS.

4–18. TOP AND BOTTOM DUST COVER REMOVAL.

4-19. To remove the top and bottom dust covers from the Main Frame, remove the screws that secure each dust cover to the chassis and lift covers away. Reverse above procedure for replacement.

TABLE 4-1

SYSTEMATIC TROUBLESHOOTING PROCEDURES

Step No.	Symptom	Test Procedure	If Indication is Normal	If Indication is Abnormal	Assy No.	Dwg No.	Paragraph
1	Panel lights do not turn ON (Figure 4-4)	a. Check power plug connections and fuse.	a. Go to step b.	a. Correct connection or replace fuse.	Rear Panel		
		b. Check panel lights for burn-out.	b. Go to step c.	b. Replace panel lights.			
		c. Check power switch.	c. Go to step d.	c. Replace power switch.			
		d. Check transformer.		d. Return instrument to factory for transformer replacement.			
2	Panel lights do not turn OFF when POWER pushbutton is pressed.	a. Check power switch.	a. Go to step b.	a. Replace power switch.			
		b. Look for short circuit across switch leads.		b. Remove short circuit.			
3	Improper Voltages to Plug-in.	a. Substitute another Plug-in Unit.	a. Troubleshoot original Plug-in Unit.	a. Go to step 4.	Plug-in Unit		

NOTE

To check operation of voltage regulators:

1. Measure output voltage. If it is less than 80% of normal, disconnect load. If voltage returns to normal or to no more than 105% of normal, check circuit which is the load. If an outside sensing connection is used, supply current to the sensing connection, and check effect of varying current on output voltage.

2. With circuit loaded, measure voltages in the regulator circuit. If any voltages are more than ± 10% from voltages shown on the schematic, check immediately adjacent transistor, diode, or integrated circuit. Next check capacitors for leakage. Then check resistors for changed values of resistance.

3. If output voltage is higher than normal, suspect a shorted series regulator transistor or one of the driver transistors. Check voltages within the circuit to locate bad part.

4. If output voltage is zero, disconnect load and check output voltage when circuit is turned back on. Refer to Step 1 concerning external sensing. A fold-back circuit is used in some regulators to protect the series regulator transistors. The circuit is principally a Zener diode and a transistor connected to short out the operation if output voltage drops too low. Check this circuit for faulty operation if output voltage is zero with no load.

4	Improper Voltage:						
	a. +20 VDC not proper (Figures 4-4 and 4-5).	a.1. Check regulator input voltage on A2	a.1. Go to step a.4.	a.1. Go to step a.2.	A2	4-5	4.56
		a.2. On Board A1, check rectifiers CR1 through CR4, and C1, R1.	a.2. Go to step a.3.	a.2. Replace defective parts. Refer to Table 4-7, step 3.6.2.			
		a.3. Check AC voltage to rectifiers.	a.3. Go to step a.4.	a.3. Return instrument to factory for transformer replacement.			

TABLE 4-1 (Continued)

Step No.	Symptom	Test Procedure	If Indication is Normal	If Indication is Abnormal	Assy No.	Dwg No.	Paragraph
4	Improper Voltage Continued						
		a.4. Check +20 VDC Regulator on A2.	a.4. Troubleshoot Plug-in Unit for improper load.	a.4. Repair Regulator.			
	b. -20 VDC not proper (Figures 4-4 and 4-5).	b.1. Check regulator input voltage.	b.1. Go to step b.3.	b.1. Go to step b.2.	A2	4-5.	4-61.
		b.2. On Board A1, check rectifiers CR5 through CR8, and C2, R1.	b.2. Go to step b.3.	b.2. Replace defective parts. Refer to Table 4-7, step 3.6.2.2.	A1	4-4.	4-51
		b.3. Check AC voltage to rectifier.	b.3. Go to step b.4.	b.3. Return instrument to factory for transformer replacement.			
		b.4. Check -20 VDC Regulator on A2.	b.4. Troubleshoot Plug-in Unit for improper load.	b.4. Repair Regulator.	A2	4-5.	4-61.
	c. +10.5 VDC not proper (Figure 4-6).	c.1. On Board A2, check output of +20 regulator.	c.1. Go to step c.2.	c.1. Go to step 4.a.	A2	4-6.	4-66.
		c.2. Check +10.5 VDC Regulator on A2.	c.2. Troubleshoot Plug-in Unit for improper load.	c.2. Repair Regulator. Refer to Table 4-7, step 3.6.2.3.			
	d. -10.5 VDC not proper (Figure 4-7).	d.1. On Board A2, check output of -20V Regulator.	d.1. Go to step d.2.	d.1. Go to step 4.b.	A2	4-7.	4-70
		d.2 Check -10.5V Regulator on A2.	d.2. Troubleshoot Plug-in Unit for improper load.	d.2. Repair Regulator. Refer to Table 4-7, step 3.6.2.4.			
	e. +62 VDC not proper (Figures 4-4 and 4-8).	e.1. On Board A1, check rectifiers CR9 through CR12 and C3, R3.	e.1. Go to step e.2.	e.1. Replace defective parts.	A1	4-4.	4-51
		e.2. Check +62 VDC Regulator on A3.	e.2. Check loads on +62 VDC lines.	e.2. Repair Regulator. Refer to Table 4-7, step 3.6.2.5.	A3	4-7.	4-76
	f. -62 VDC not proper (Figures 4-4 and 4-9).	f.1. On A1, check rectifiers CR13 through CR16 and C4, R4.	f.1. Go to step f.2.	f.1. Replace defective parts.	A1	4-4.	4-51
		f.2. Check -62 VDC Regulator on A3.	f.2. Check loads on -62 VDC line.	f.2. Repair Regulator. Refer to Table 4-7, step 3.6.2.5.	A3	4-7.	4-80
	g. + Program not proper (Figure 4-10).	g.1. Check output of +62 VDC Regulator on A3.	g.1. Go to step g.2.	g.1. Go to step 4.e. Refer to Table 4-7, steps 3.6.2.7 and 3.6.2.8.	A3	4-7.	4-76
		g.2. Check + Program Regulator	g.2. Troubleshoot Plug-in Unit for improper load or feedback.		A3	4-8.	4-85

TABLE 4-1 (Continued)

Step No.	Symptom	Test Procedure	If Indication is Normal	If Indication is Abnormal	Assy No.	Dwg No.	Paragraph
4	Improper Voltage Continued						
	h. - Program not proper (Figure 4-11).	h.1. Check output of -62 VDC Regulator on A3.	h.1. Go to step h.2.	h.1. Go to step 4.f.	**A3**	4-7.	4-80
		h.2. Check - Program Regulator.	h.2. Troubleshoot Plug-in Unit for improper load, or feedback.	h.2. Repair Regulator. Refer to Table 4-7, steps 3.6.2.9 and 3.6.2.10.	**A3**	4-8.	4-88
5	Negative ramp to plug-in not proper.	a. Replace Plug-in Unit.	a. Troubleshoot original Plug-in Unit.	a. Go to step 5.b.	Plug-in Unit		
		b. On Board A4, check for positive ramp input at pin 25.	b. Go to step 5.c.	b. Go to step 5.d.	**A4**	4-10.	4-95
		c. On Board A4, check operation of A3 and Q21 (emitter follower). Circuit should invert positive ramp input.	c. Adjust output with R76 and R83.	c. Replace defective parts. Refer to Table 4-7, step 3.4.			
		d. Check for proper control settings to have a trigger for the ramp.	d. Go to step 5.e.	d. Correct the control settings.	Front Panel Controls		
		e. On Board A6, check for trigger pulse at pin 11 of IC3-B (sweep flip-flop)	e. Go to step 5.f.	e. Go to step 5.h.	**A6**	4-9.	4-92
		f. Check A1 and A2 for ability to detect positive and negative sweep voltage limits.	f. Go to step 5.g.	f. Replace defective parts. Refer to Table 4-7, step 3.4.			
		g. Check A3 and Q21 on A4.	g. Check other parts in sweep inversion circuit.	g. Replace defective parts. Refer to Table 4-7, step 3.4.	**A4**	4-10.	4-95
		h. Check trigger circuit parts, Q1, Q7, IC3-A, IC4-A, IC1-A, IC4-B on A6.	h. Troubleshoot complete trigger circuit, using voltages shown as normal on schematic, as indicators.	h. Replace defective parts. Refer to Table 4-7, step 3.4.	**A6**	4-9.	4-92
6	Insufficient RF Output	a. Substitute another plug-in unit.	a. Troubleshoot original Plug-in Unit.	a. Go to step 6.b.	Plug-in Unit		
		b. Install Extender Cable, and check each voltage supplied by the 6600.	b. Troubleshoot Plug-in Units.	b. Go to step 3.			
7	RF Amplitude Varies (Figure 4-5).	a. This control is a function of the Plug-in. See Plug-in troubleshooting procedure in Plug-in Manual.					

TABLE 4-1 (Continued)

Step No.	Symptom	Test Procedure	If Indication is Normal	If Indication is Abnormal	Assy No.	Dwg No.	Paragraph
8	No Blanking	a. Check controls; be sure that blanking is called for.	a. Go to step 8.b.	a. Reset controls.	Front Panel Controls		
		b. Check whether blanking signal appears at input to Plug-in Unit.	b. Troubleshoot Plug-in Unit.	b. Go to step 8.c.	Plug-in Unit		
		c. Check blanking signal from Q8 and from Q7 of A6.	c. Troubleshoot Plug-in Unit.	c. Replace bad transistor or troubleshoot ramp generator (step 13). Refer to Table 4-7, step 3.4.3	A6	4-12.	4-106
9	±Blank not proper.	a. Check circuit of Q1 and Q2 on rear panel board, A7.	a. Go to step b.	a. Replace faulty parts.	A7	4-18.	4-129
		b. Check circuit of Q9, Q10, Q13 and Q14 on A6	b. Go to step 13.	b. Replace faulty parts.	A6	4-12.	4-106
10	No internal amplitude modulation	a. Check controls; be sure that AM pushbutton is in ON position, and that rear panel EXT switch is in INT position.	a. Go to step b.	a. Push AM button in.	Rear and Front Panel Controls.		
		b. Check for square wave at input to Plug-in Unit, pin 22 of Plug-in Connector.	b. Troubleshoot Plug-in Unit.	b. Go to step 9.c.	Plug-in Unit		
		c. Check for square wave at collector of A4Q24.	c. Look for disconnect between this point and Plug-in Unit.	c. Go to step 9.d.	A4	4-16.	4-119
		d. Check voltages in square wave multivibrator of A4. See Figure 4-20.	d. Replace Q24.	d. Check parts adjacent to faulty voltage readings in schematic. Refer to Table 4-7, step 3.5.6			
11	No external amplitude modulation.	a. Check controls. Be sure AM button on front panel is ON and EXT AM MOD switch on rear panel is in EXT.	a. Go to step 11.b.	a. Correct switch position.	Front and Rear Panel Controls.		
		b. Change controls to INT AM MOD. Look for square wave modulation.	b. Check A4Q17; replace or trace signal from input jack to emitter of A4Q17.	b. Check through step 10.	A4	4-16.	4-119
12	Markers not proper (Figure 4-16).	a. Check Board A4, F_o, M1, and M2 Marker Generators and Marker Output Amplifiers. Compare voltages and wave forms with those in Figure 4-16.	a. Check MARKER amplitude pot. This provides clipping level.	a. Repair faulty circuit. Refer to Table 4-7, step 3.5.5	A4	4-11.	4-100

TABLE 4-1 (Continued)

Step No.	Symptom	Test Procedure	If Indication is Normal	If Indication is Abnormal	Assy No.	Dwg No.	Paragraph
13	Output Frequencies not proper	a. Check frequency control voltages to Plug-in Unit for CW Manual Control OFF. Voltages and frequencies should match calibration table of Plug-in Unit. Tuning voltages should match positions of F_o.	a. CW operation is proper. Go to step 13.b.	a. Check Plug-in Unit by replacing with another. If operation of second Plug-in Unit is faulty go to step 13.c.	Plug-in Unit		
		b. Operate 6600 at Full Band, internal sweep. Check frequency marker uniformity on oscilloscope (Singer Marker Generator for Model 7300).	b. Use same setup for other sweep functions. Trace sweep signals through tuning. Voltage controls circuit, Figure 4-10.	b. Go to step 13.c.	Front Panel Controls **A4**	4-10.	4-95
		c. If linearity of sweeps or relation of tuning voltage to F_o position are not proper, trace tuning signals back through circuits of Figure 4-10.	c. When proper sweep is found, replace faulty part between point of proper sweep and point of improper sweep.	c. If abnormal sweeps are found at the Up Ramp input to Figure 4-10, go to paragraph 4-92 and the Up Ramp Generator circuit, Figure 4-9.	**A6**	4-9.	4-92
14	Sweep speeds not proper.	a. Set sweep VAR control at CAL. Check whether all sweeps are out in the same direction.	a. If all sweeps are out in the same direction, replace capacitor C12, on A6.	a. If time errors are in the same direction except for one, replace R3, R5, R7 or R10, to correct the single timing error. b. If errors are random, check A1, A2, A3. Replace bad unit. Refer to Table 4-7, step 3.4.2	**A6**	4-9.	4-92
15	Frequency sweep not proper.	a. Check control positions, including rear panel controls.	a. Go to step 15.b.	a. Correct control settings.	Front Panel Controls		
		b. Check voltage ramp into Plug-in Unit. Be sure that voltage sweep is proper polarity and amplitude.	b. Troubleshoot Plug-in Unit.	b. Go to step 13.	Plug-In Unit		
16	Sweep Output not proper.	a. Check Relay K1 on A4.	a. Go to step 15.b.	a. Replace relay.	**A4**	4-10.	4-95
		b. Check Amplifier A2 on Board A4.	b. Go to step 16.c.	b. Replace A2.			
		c. Check input ramp to A2. This should be the negative voltage ramp.	c. Check power connections to A2.	c. Go to step 13.			
17	VPF Output not proper.	a. Go to step 16. This is the same signal as SWEEP.					

Step No.	Symptom	Test Procedure	If Indication is Normal	If Indication is Abnormal	Assy No.	Dwg No.	Paragraph
18	Control switches do not operate properly	a. Check operation of Control Board A5. Using Table 4-2, determine whether signals pass ıals through relays in the proper direction.		a. Refer to Figures 4-15 and 4-16, and to the A5 schematic which is in Section 6.	**A5**	4-10. 4-11.	4-95. 4-100.

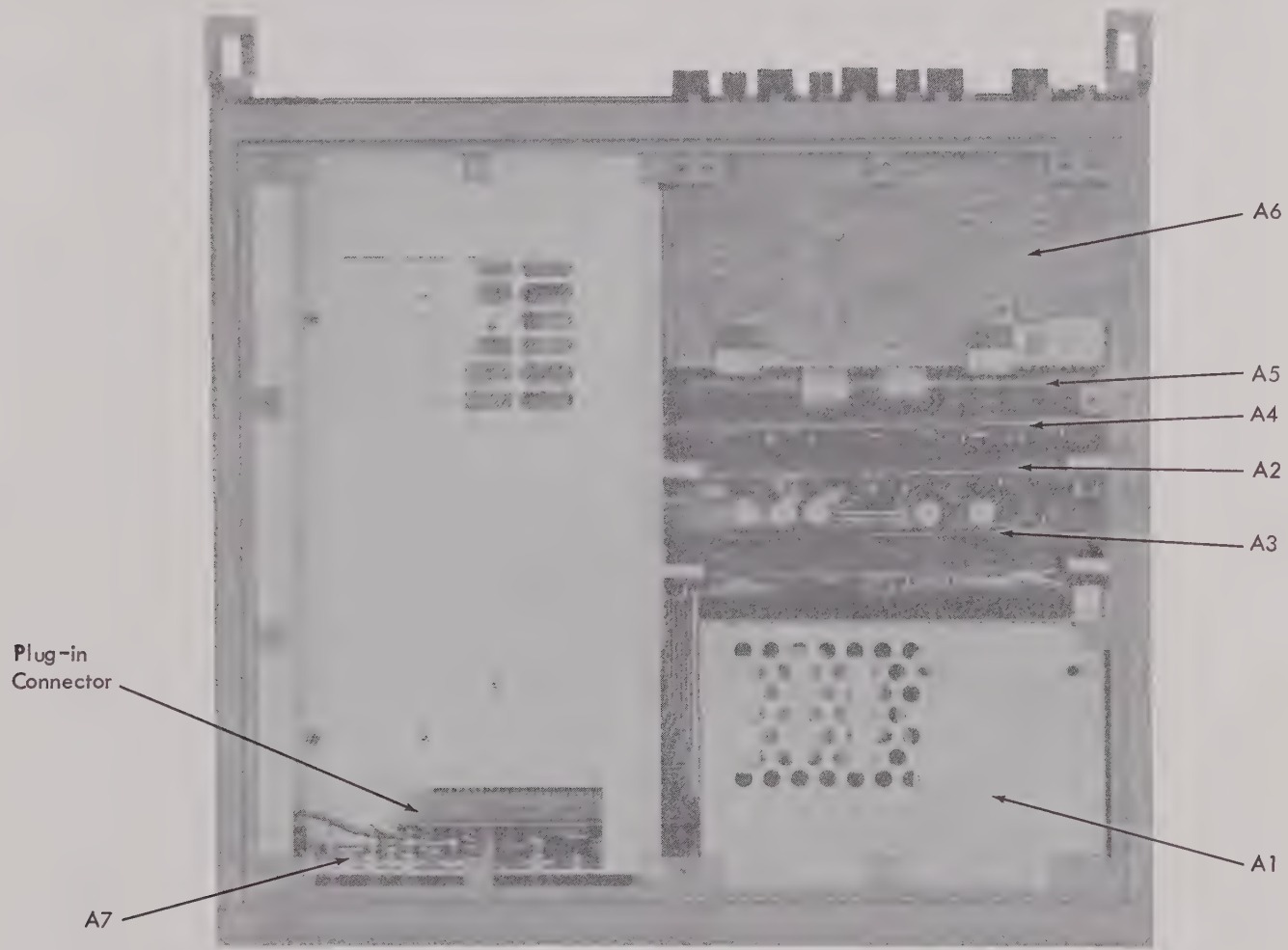


Figure 4-1. Model 6600, Bottom View, Bottom Cover Removed, Assembly Location

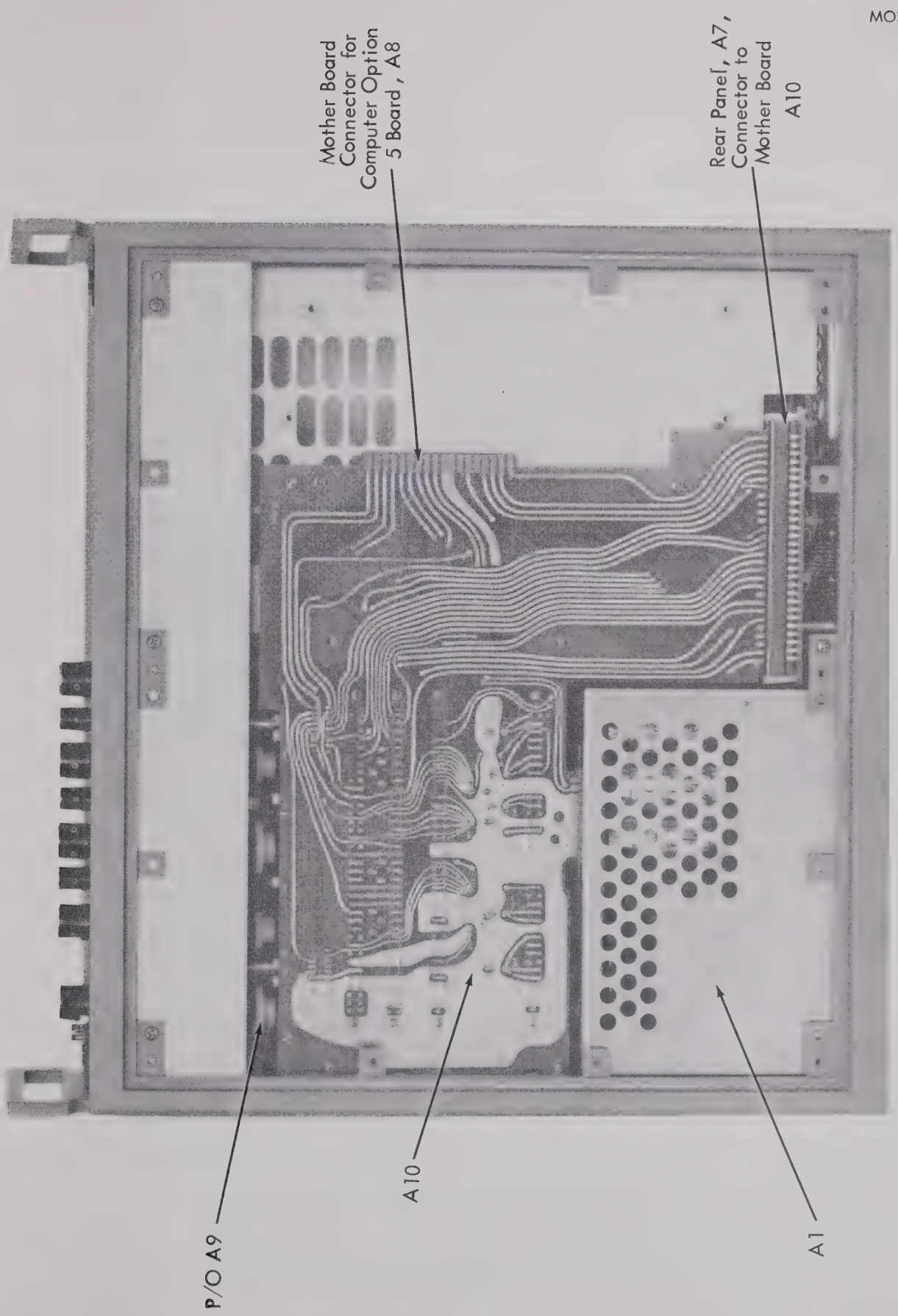


Figure 4-2. Model 6600, Top View, Top Cover Removed, Assembly Location

A - Power Supply, A1, Screws
B - Rear Panel, A7, Screws

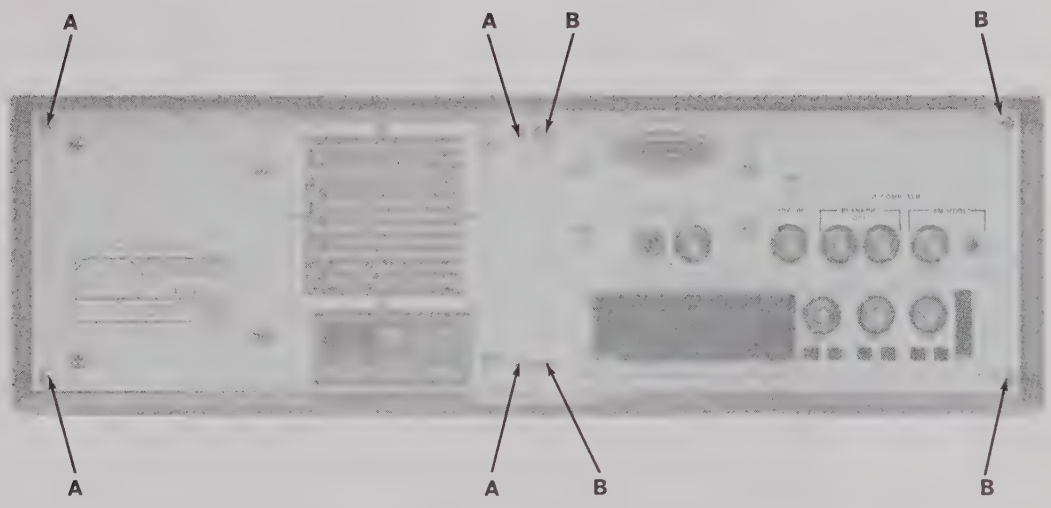


Figure 4-3. Model 6600, Rear View, Mounting Screw Location

4–20. SIDE DUST COVER REMOVAL.

4-21. To remove the side dust covers from the Main Frame, remove the screws that secure each dust cover to the chassis and lift covers away. Reverse above procedure for replacement.

4–22. PRINTED CIRCUIT BOARD REMOVAL.

4-23. Printed Circuit Board locations are shown in Figure 4-1 and 4-2.

4–24. POWER SUPPLY MODULE, A1.

4-25. To remove Power Supply Module, A1:

a. Remove four large round head screws at corners of power supply panel. See Figure 3-3(A).

b. Slide Power Supply out of chassis. One connector, PCB type, mates with the Mother Board just under the top cover. This does not appreciably restrict motion of the Power Supply.

4–26. REGULATOR #1 BOARD, A2.

4-27. To remove Regulator #1 Board, A2:

a. Remove bottom cover. See paragraph 4-18. Keep Main Frame inverted.

b. Rock the board forward and back slightly to release the seal formed between the board and a heat sink by heat-conducting grease.

c. Pull the board straight up, out of its connector socket.

4–28. REGULATOR #2 BOARD, A3.

4-29. To remove Regulator #2 Board, A3, follow the procedure of paragraph 4-26.

4–30. MODULATION BOARD, A4.

4-31. To remove the Modulation Board, A4:

a. Remove bottom cover. See paragraph 4-18. Keep Main Frame inverted.

b. Pull the board straight up, out of its connector socket.

4–32. CONTROL BOARD, A5.

4-33. To remove the Control Board, A5:

a. Remove bottom cover. See paragraph 4-18. Keep Main Frame inverted.

b. Disconnect two flat-wiring connectors from A5.

CAUTION

The pins in the plugs are small and sharp. Handle gently to prevent puncturing your skin and bending the pins.

c. Pull the board straight up out of its connector socket.

4–34. RAMP GENERATOR BOARD, A6.

4-35. To remove the Ramp Generator Board, A6:

a. Remove bottom cover. See paragraph 4-18. Keep Main Frame inverted.

b. Remove right side panel. See paragraph 4-20.

c. Remove corner post at right end of front panel by removing four screws.

d. Remove eight knobs from front panel.

e. Remove nuts from MARKER and VAR (Time) controls.

f. Remove front panel by pulling or lifting against no restraint.

g. Remove two screws near end of aluminum subpanel.

h. Disconnect two flat wiring connectors at rear end of Board A6. See Caution in paragraph 4-33.

i. Disconnect ground lead from BNC SWEEP jack at lower right of front panel.

j. Pull and/or push Board A6 and subpanel forward, to remove from chassis.

4–36. REAR PANEL BOARD, A7.

4-37. To remove Rear Panel Board, A7:

a. Remove Power Supply, A1. See paragraph 4-24.

b. Remove four large screws near corners of the rear panel (Figure 4-3, index B).

c. Remove vertical post at center of rear opening. This requires removal of two screws, from top and bottom of post.

d. Remove rear panel board and rear panel, which is connected to it, by sliding it back out of the chassis.

4–38. POTENTIOMETER AND FUNCTION BOARD, A9.

4-39. To remove the Potentiometer and Function Board, A9:

a. Remove top and bottom covers; see paragraph 4-18.

b. Remove both side covers; see paragraph 4-20.

c. Remove both front corner posts (four screws each).

d. Disconnect flat wiring connectors from A5. See Caution in paragraph 4-33.

e. Remove three screws from top front flange of the cabinet. These hold the tuning control mechanism to the cabinet.

f. Slide the tuning control mechanism and Potentiometer Board and Function Board straight forward, as a unit, to remove them from the cabinet.

g. DO NOT disassemble the tuning control from the Potentiometer and Function Boards. Parts on the printed circuit may be removed and replaced with no further disassembly.

4–40. MOTHER BOARD, A10

4-41. To remove the Mother Board:

a. Remove the top cover. See paragraph 4-18.

b. Remove Boards A2 through A5. See paragraphs 4-26 through 4-32.

c. Remove six screws which hold the Mother Board in place. DO NOT remove the three small screws near the center of the Board.

d. Slide the Mother Board forward to disconnect it from the Power Supply connector. Lift it from the cabinet.

4–42. REPLACEMENT OF BOARDS.

4-43. To replace boards, reverse the procedures used to remove them.

4–44. PRELIMINARY TROUBLESHOOTING PROCEDURES.

4-45. To find the source of apparent out-of-specification operation of an instrument:

a. Be sure that power is supplied to each instrument requiring power. Check fuses, switches, whether fans operate, whether lamps are lit.

b. Check position of each control. Be sure that two pushbuttons, within an interacting group, are not depressed at the same time. If two are, depressing a third button will normally release the first two.

c. Be sure that interconnecting plugs are firmly in their sockets.

d. If a warm-up time is indicated in the operating instructions, do not expect specified operation before that time is ended.

e. If another instrument of the same model is available, substitution of an operating assembly of the number (like A7) as designated in the Assembly Number column of the troubleshooting chart, may show that the problem is in the replaced assembly. Recognize, however, that two or more troubles are possible in any instrument, at one time. Substitute assemblies one at a time, without replacing the originals, until the trouble is corrected. Then replace original assemblies, one at a time. If trouble returns, the last replaced assembly is at fault, also.

4-46. It is assumed in the Troubleshooting Chart which follows, that these preceding steps have been taken, except for number 5, which requires an operating instrument as a source of assemblies.

4–47. TEST EQUIPMENT REQUIRED.

4-48. Test equipment required for troubleshooting is listed in Table 2-4. Standard hand tools are required for disassembly of the instrument.

4–49. DETAILED CIRCUIT DESCRIPTIONS.

4-50. Following are detailed descriptions of the circuits used in the Model 6600 Main Frame.

4.51. **A1** POWER SUPPLY, FIGURE 4-4.

4-52. The Power Supply module supplies required DC power to the 6600A main frame and to the Plug-in Unit. It is a plug-in assembly consisting of a power input module, a power transformer, rectifiers, filters, and a fan. The power input module conforms to standards of the International Electrotechnical Commission and has a fuse holder, and RFi filter, and a 115V/230V operation and multiple secondaries to provide the range of voltages used in the instrument. Silicon diode bridges and computer grade electrolytic capacitors form the rectifier and filter circuits. A 50-60 Hz fan is provided for cooling purposes.

4-53. Plug-in power supplies for other voltages and power line frequencies can be provided on special order.

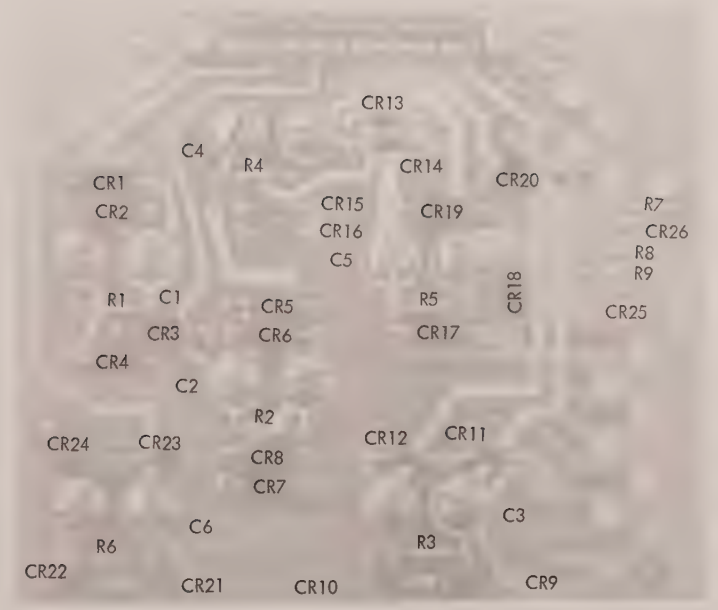
4-54. **A2** REGULATOR #1 BOARD

4-55. The A2 Regulator #1 Board regulates plus and minus 20 volts and plus and minus 10.5V. The plus and minus 20V regulators provide general purpose power, and the plus and minus 10.5V are used as low noise precision references in the instrument. Circuits are standard series regulators.

4.56. +20V REGULATOR, FIGURE 4-5.

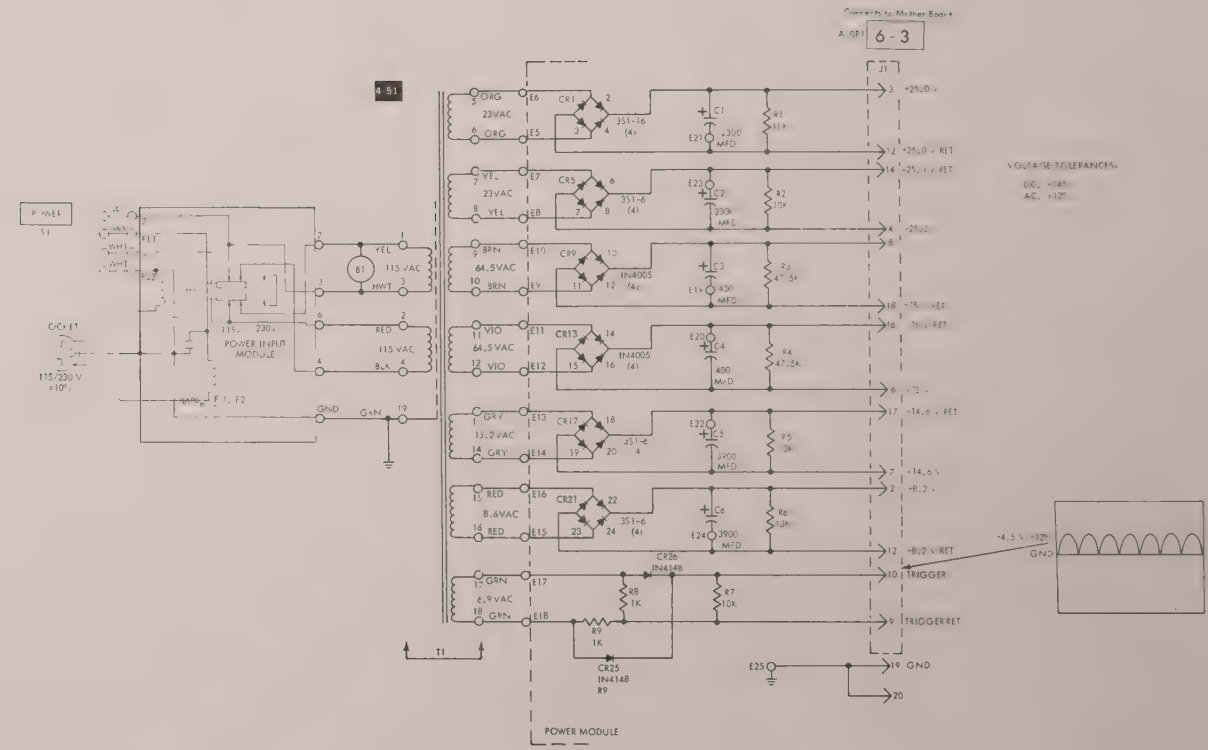
4-57. The +20V Regulator supplies stable +20 volts for general use in the Model 6600. Power input is +28V. The reference voltage is across CR13, a zero temperature coefficient zener diode.

4-58. The differential amplifier A3 compares the reference voltage with a portion of the output voltage determined by the setting of R46. Output of A3, via Q16, drives Q12, the series regulator, which holds output voltage constant.



A1

Parts Locations



A1

4 - 4.

Figure 4-4. Power Supply, A1

4-59. Excess output current turns on Q13, which takes current from the base of Q12, thereby limiting output current. The circuit is also protected against extreme loads by Zener diode CR11. If the limited output current cannot hold the output voltage up to 5 volts, CR11 conducts, and Q13 draws more current, thereby folding the output current and voltage back to zero, except for less than 5 mA flowing through CR11.

4-60. CR14 is a load protector, preventing voltages in excess of 22 volts across the load.

4-61. -20V REGULATOR, FIGURE 4-5.

4-62. The -20V Regulator supplies stable -20 volts for general use in the Model 6600A. Power input is -28V. The reference voltage is +20 volts.

4-63. The differential amplifier A4 compares the reference voltage with the output voltage with exact balance determined by the setting of R41. Output of A4 via Q17, drives Q15, the series regulator, which holds output voltage constant, so that the input to A4 is ± 1 mV from ground.

4-64. Excess output current turns on Q14 which takes current from the base of Q15, thereby limiting output current. The circuit is also protected against extreme loads by Zener diode CR12. If the limited output current cannot hold the output voltage up to -5 volts, CR12 conducts, and Q14 draws more current, thereby folding the output current and voltage back to zero, except for less than 5 mA flowing through CR12.

4-65. CR15 is a load protector, preventing voltages in excess of 22 volts across the load.

4-66. +10.5V REGULATOR, FIGURE 4-6.

4-67. The +10.5V Regulator supplies stable +10.5 volts for reference use in the Model 6600A. Power input is +20 volts. The reference voltage is across C4, a zero temperature coefficient Zener diode, which is further stabilized by a positive temperature coefficient resistor-heater in the 45T1-1 oven. Oven power is taken from +28 volts, but voltage to the oven heater is held stable by Q6.

4-68. The differential cascode amplifier formed by Q3 Q4, and Q5 compares the reference voltage with a portion of the output voltage determined by the setting of R10. Output is amplified by A1, which drives the series regulator Q1, which holds output voltage constant.

4-69. Excess output current turns on Q2, which takes current from the base of Q1, thereby limiting output current.

4-70. -10.5V REGULATOR, FIGURE 4-6.

4-71. The -10.5V Regulator supplies stable 10.5 volts for reference use in the Model 6600A. Power input is -20V. The reference voltage is +10.5 volts.

4-72. The differential cascode amplifier formed by Q9, Q10, and Q11, compares the reference voltage with the output voltage with exact balance determined by the setting of R22. Output is amplified by A2, which drives the series regulator Q8, which holds output voltage constant.

4-73. Excess output current turns on Q7, which takes current from the base of Q8, thereby limiting output current.

4-74. REGULATOR #2 BOARD **A3**

4-75. The A3 Regulator #2 Board regulates +62V, +Program volts, and -Program volts. The regulator circuits are similar to the regulator circuits on the A2 Regulator #1 Board. Descriptions of the individual circuits follow. A schematic of all of the circuits on the board is in Section VI.

4-76. +62V REGULATOR, FIGURE 4-7.

4-77. The +62V Regulator supplies stable +62 volts for use by the +Program Voltage Regulator. Power input is +67V. The reference voltage is -10.5 volts.

4-78. The differential amplifier A3 compares the reference voltage with the output voltage, via voltage divider R6 and R7. Output of A3 via Q3 drives Q1, the series regulator, which holds output voltage constant, so that the input to A3 is ± 1 mV from ground. For this balance, output voltage is +62.0 volts.

4-79. Excess output current turns on Q2, which takes current from the base of Q1, thereby limiting output current. The circuit is also protected against extreme loads by Zener diode CR1. If the limited output current cannot hold the output voltage up to +20 volts, CR1 conducts, and Q2 draws more current, thereby folding the output current back to zero, so that the output voltage is held at +19 volts by CR15, which feeds current from the +20 volt supply.

4-80. -62V REGULATOR, FIGURE 4-7.

4-81. The -62V Regulator supplies stable -62 volts for use by the -Program Voltage Regulator. Power input is -67V. The reference voltage is +10.5 volts.

4-82. The differential amplifier A2 compares the reference voltage with the output voltage via voltage divider R14 and R15. Output of A2 via Q4 drives Q6, the series regulator, which holds output voltage constant, so that the input to A2 is ± 1 mV from ground. For this balance, output voltage is -62.0 volts.

4-83. Excess output current turns on Q5 which takes current from the base of Q6, thereby limiting output current. The circuit is also protected against extreme loads by Zener diode CR5. If the limited output current cannot hold the output voltage up to -20 volts, CR5 conducts, and Q5 draws more current, thereby folding the output current back to zero, so that the output voltage is held at -19 volts by CR16, which feeds current from the -20 volt supply.

4-84. +PROGRAM VOLTAGE REGULATOR, FIGURE 4-8.

4-85. The +Program Voltage Regulator supplies required positive voltage for use in the Plug-in Unit. Power input is +62V. The reference voltage is -10.5 volts.

4-86. The differential amplifier A3 compares the reference voltage with the output voltage via voltage divider R28, R29, R30, and R_p. Output of A3 via Q1 drives Q7, the series regulator, which holds output voltage constant, so that the input to A3 is ± 1 mV from ground. Output voltage is determined by R_p (or an equivalent circuit), which is in the Plug-in Unit.

4-87. Excess output current turns on Q8, which takes current from the base of Q7, thereby limiting output current. The circuit is protected against extreme loads by Q9, Q10, and CR9. If current is limited by action of Q8, Q9 is turned ON. This causes no action until excess current drain causes the emitter voltage on Q9 to drop below 20 volts. If this happens the 20 volt buss supplies current to the +Program Voltage load, via CR9 and Q9. If load current increases further, Q10 conducts, and base current to Q9 is reduced. This limits the amount of current drawn from going negative.

4-88. -PROGRAM VOLTAGE REGULATOR, FIG 4-8.

4-89. The -Program Voltage Regulator supplies required negative voltage for use in the Plug-in Unit. Power input is -62V. The reference voltage is +10.5 volts.

4-90. The differential amplifier A4 compares the reference voltage with the output voltage via voltage divider R34, R35, R36, and R_p. Output of A4 via Q12 drives Q6, the series regulator, which holds output voltage constant, so that the input to A4 is ± 1 mV from ground. Output voltage is determined by R_p (or an equivalent circuit) which is in the Plug-in Unit.

4-91. Excess output current turns on Q13 which takes current from the base of Q16, thereby limiting output current. The circuit is protected against extreme loads by Q14, Q15, and CR12. If current is limited by action of Q13, Q14 is turned ON. This causes no action until excess current drain causes the emitter voltage on Q14 to drop below 20 volts. If this happens, the 20-volt bus supplies current to the +Program Voltage load via CR12 and Q14. If load current increases further, Q15 conducts, and base current to Q14 is reduced. This limits the amount of current drawn from the +20 volt supply. CR11 prevents -Program Voltage from going negative.

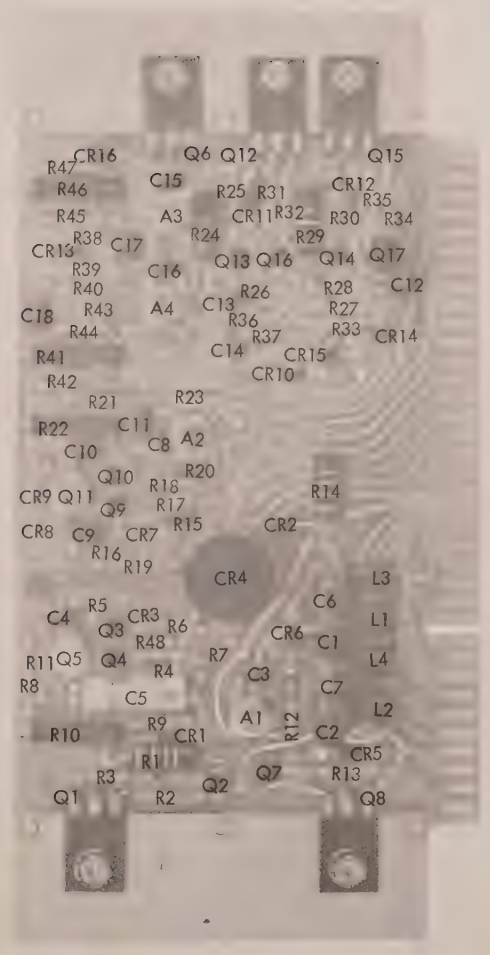
4-92. RAMP GENERATOR **A6** FIGURE 4-9.

4-93. The Ramp Generator A6 produces the voltage ramp which causes the frequency sweep in the Plug-in Unit. The basic sweep circuit is the differential amplifier A3 in an integrated circuit which uses C12 as the integrating capacitor. The circuit is unusual in that the power supply terminals of the amplifier (terminals 4 and 7) are used as the output. The normal output terminal, 6, is grounded through R37. Q11 and Q12 form an amplifier which feeds back through C12 into terminal 2 of the amplifier, the inverting input connection. Timing is determined by resistors which are switched by switches S1, S2, S3 and S4. Current to the integrating circuit is supplied through transistors Q3 and Q4 for the plus voltage applied and through A6 and A7 for the minus voltage applied to the resistors. The regulated plus and minus 20V supplies are used to supply the current, and the switching transistors act as saturated switches so that the voltage is constant for the length of the sweep and the same from one sweep to the next. The positive-going ramp produced by negative current into this integrating circuit goes from ground potential to +10.5 volts exactly. The top voltage is detected by the differential amplifier A1 which detects difference between the output sweep voltage from the collector of Q11 and reference +10.5 volts. When the ramp voltage reaches 10.5 volts plus approximately 1 millivolt, the output of A1 switches and thereby switches the flip-flop, U3-B. The flip-flop applies 5 volts to an input of U1-B. The output of U1-B goes to ground, and the -20 volt switch is turned OFF. At the same time, U1-C applies positive 5 volts to the positive switch input, and Ramp Drive is +20 volts. The resultant negative sweep is much faster than the positive sweep because the voltage is applied through much smaller resistors. CR1 allows current from the positive drive voltage to flow through the low resistances. Negative current is restricted to high resistances. When the rapid negative sweep due to positive drive reaches ground potential, the bottom detector A2 determines this fact and switches its output so that sweep gate U4-B is partly open. When a trigger comes in through the other input to U4-B, the sweep flip-flop U3-B is flipped back. This triggers the delay one shot, U2 which applies, for approximately 4 milliseconds, positive voltage to inputs of gates U1-B and U1-C. The outputs of the gates go to ground, and both positive and negative current flow are cut off. At the end of this delay, negative drive is turned on, and the positive ramp is generated. When the ten-second switch is on, C2 is connected in parallel with C4, and the time delay is approximately 600 milliseconds.

4-94. Output of the positive ramp goes through the Manual Sweep switch S12, so that the ramp is disconnected when Manual Sweep is ON. The remove ramp generator control circuit normally clamps the 5.7V connection to 0.7 volts, in the three-way switch. This allows normal operation of the switch. When ground potential is applied to J1-4, Q16 conducts, Q15 is cut off, and Q5 is cut off. This allows voltage on the 5.7 volt connection to rise to 5.7 volts so that 5 volt inputs to Q4 and Q6 do not turn the switches ON. Ramp drive stays at ground potential until the remote ramp generator control terminal is disconnected from ground.

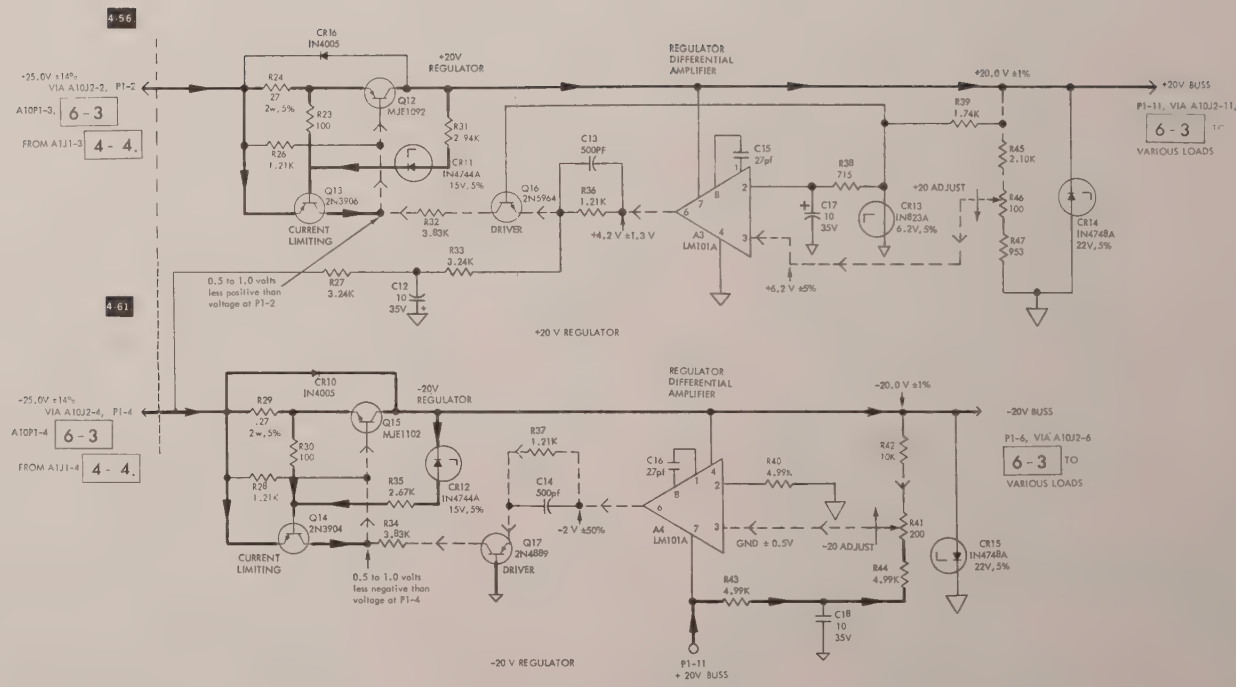
4-95. TUNING VOLTAGE CONTROLS, FIGURE 4 10.

4-96. The tuning voltage controls adjust the amplitude of and mix five tuning voltages. These are F_o and F_o vernier which are dc voltages, M1 which may be a dc voltage or a negative-going ramp, M2 which may be a dc voltage or a positive-going ramp, and ΔF which is a positive-going ramp. Amplitudes of the various voltages are controlled by the pots, which are marked for identification on this schematic. The F_o, M1 and M2 pots have trimmer pots which are used to set the exact limits over which control may be exercised. F_o vernier and ΔF pots are simple amplitude control pots with no adjustments of their limits. The signal into the ΔF pot,



A2

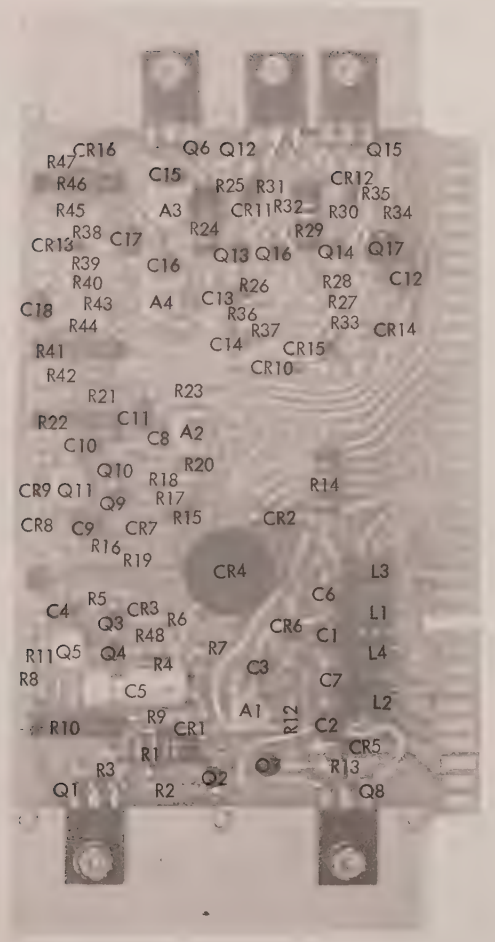
Parts Locations



A2

4-5.

Figure 4-5. ±20V Regulator, A2



A2

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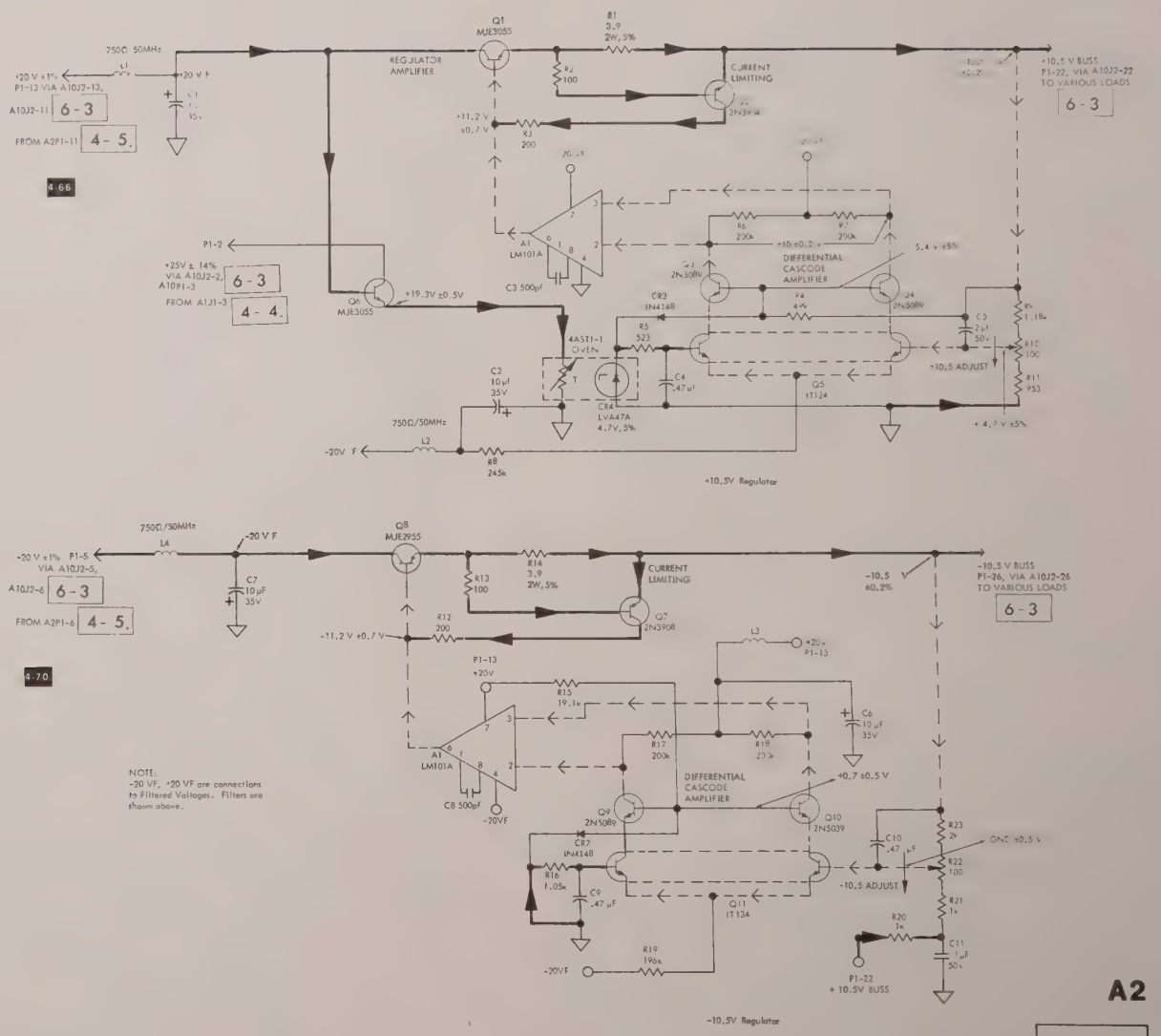
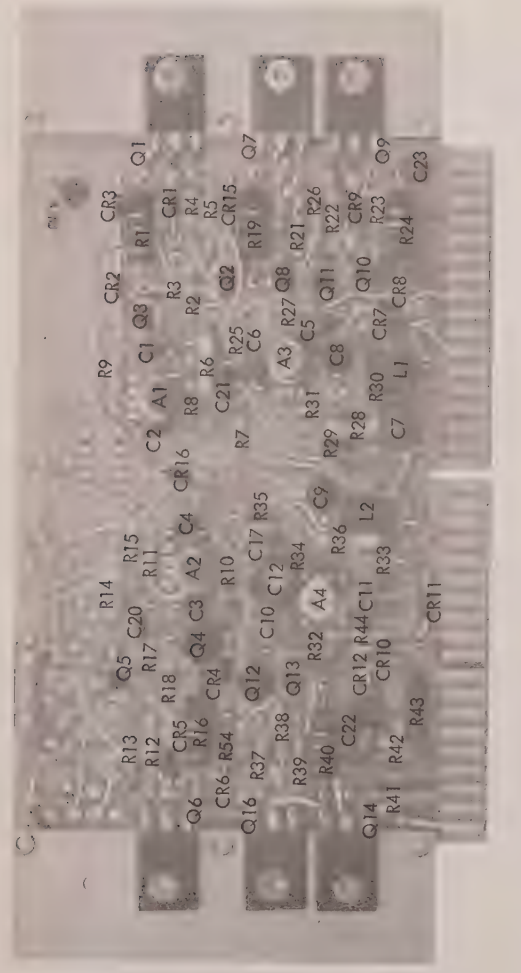


A2

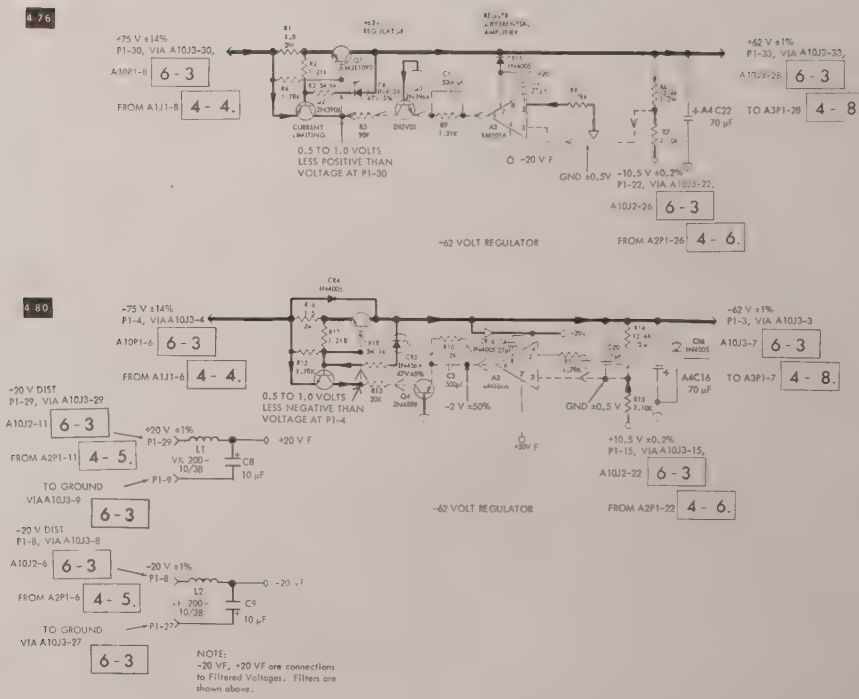
4 - 6.

Figure 4-6. ±10.5V Regulator, A2



A3

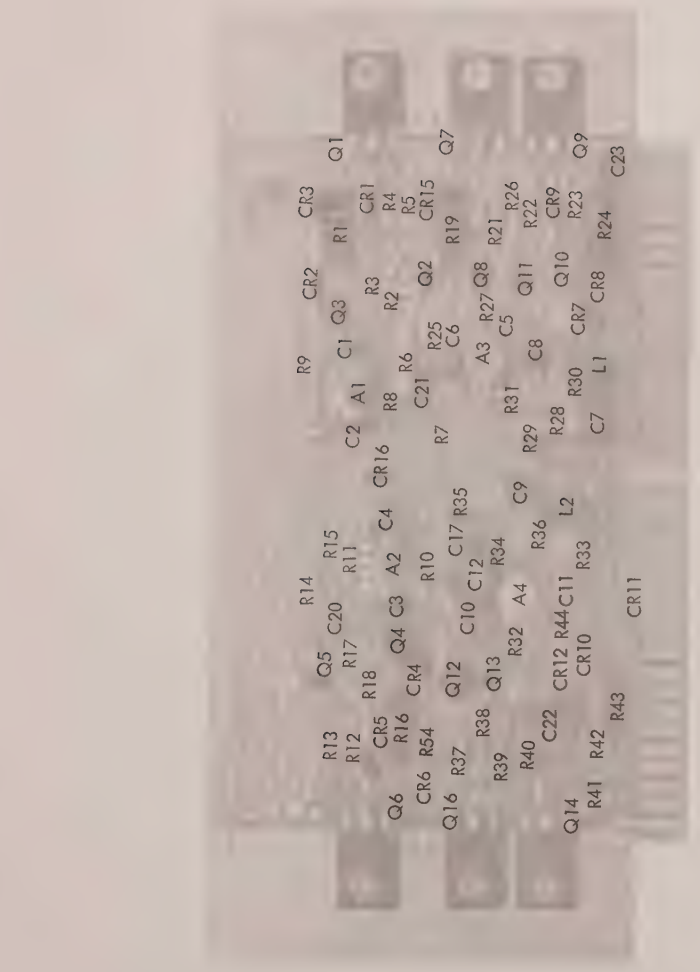
Parts Locations



A3

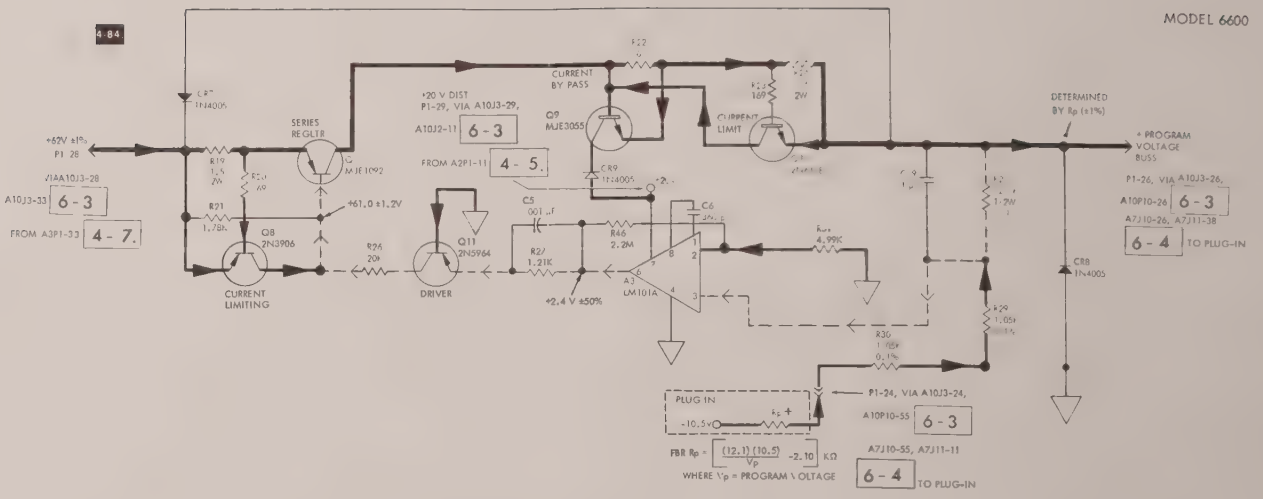
4 - 7.

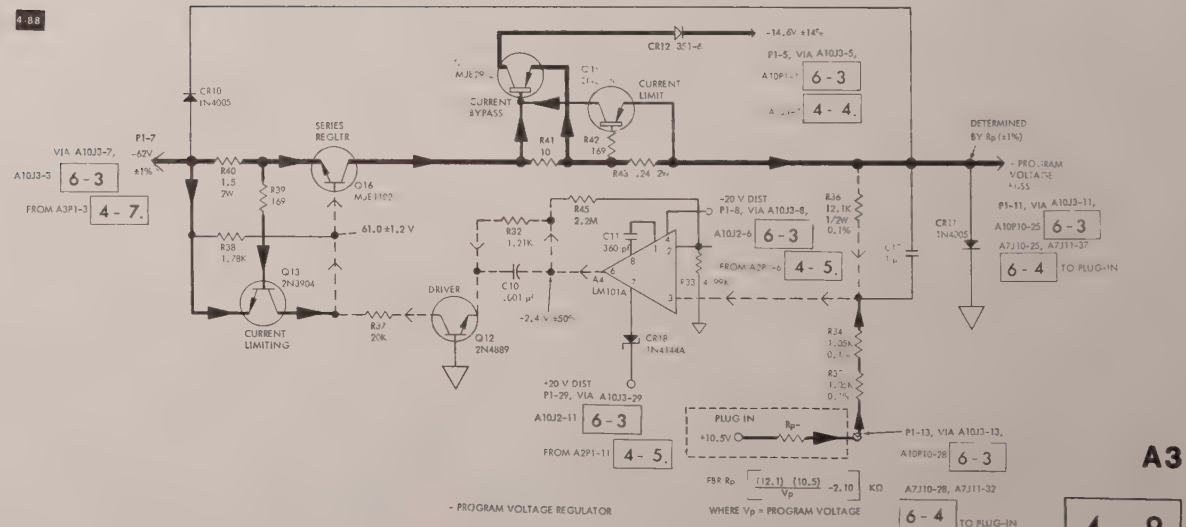
Figure 4-7. ±62V Regulator, A3



A3

Parts Locations

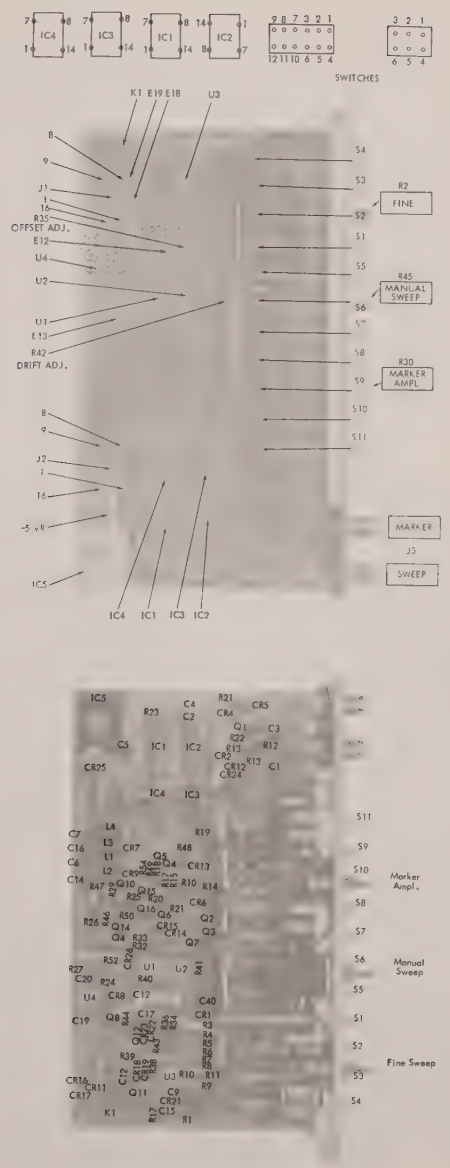




A3

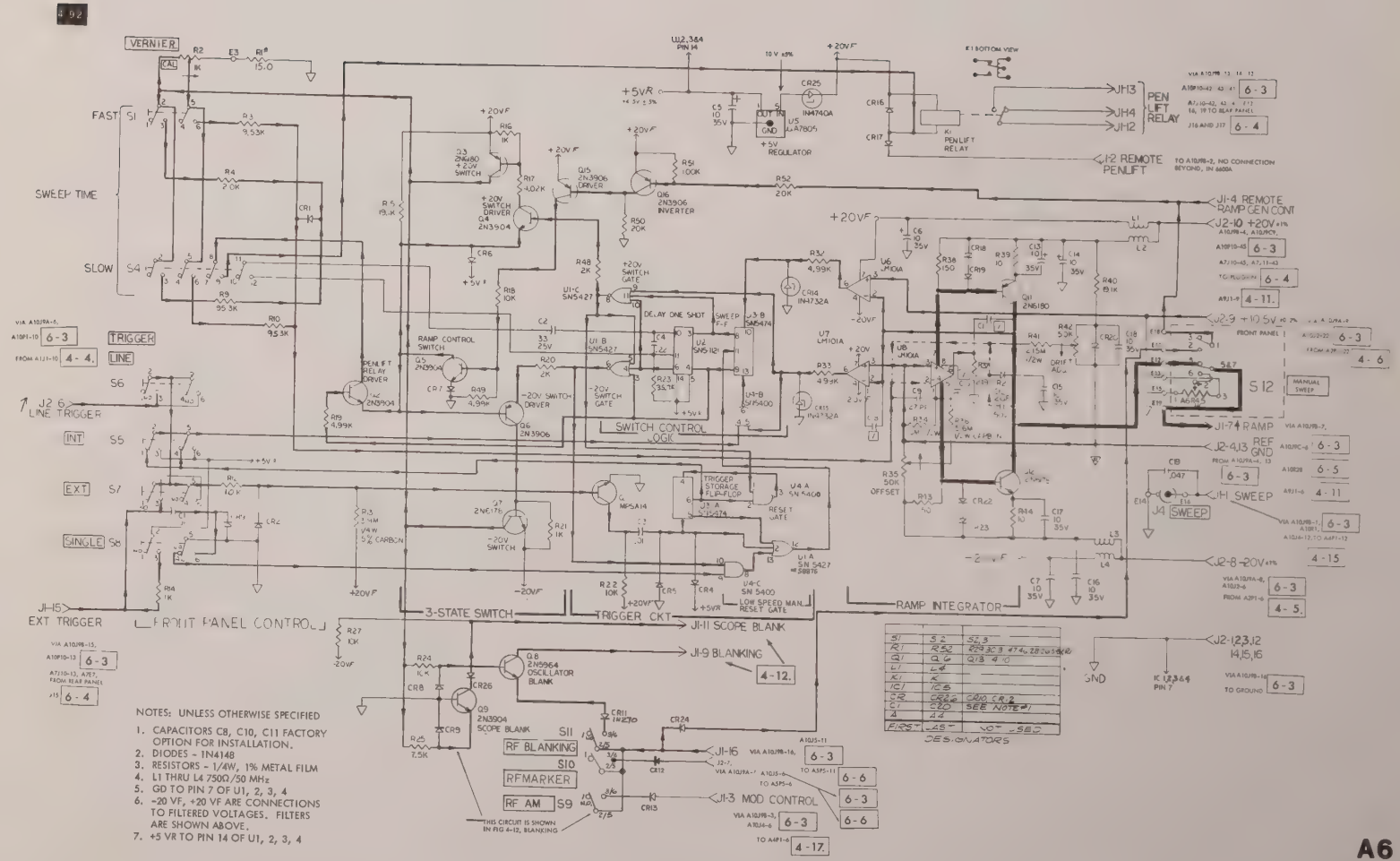
4 - 8.

Figure 4-8. ± Program Regulator, A3



A6

Parts Locations



A6

4 - 9.

Figure 4-9. Ramp Generator, A6

however, is adjusted by trimmer pots on board A4, the modulation board, at the input to the ramp booster amplifier. These trimmers adjust gain and offset, dc level, of the ramp.

4-97. The tuning voltages are mixed at the input to the ramp inverter which is amplifier A1 of the A4 board. Which tuning voltages are mixed at any particular time is determined by the settings of relays K1 through K9. Table 4-1 is a matrix of the relays and some other functions. The word ON under a relay and opposite some controlling switch position means that the relay is energized. Relay positions on the schematic are unenergized position; an energized relay will switch contacts as indicated.

4-98. Signal inputs into the ramp inverter mixer via the signal line F1 go through a 10,000 ohm resistor. Inputs to F2 also go through a 10,000 ohm resistor; however, inputs to F3 go through a 100,000 ohm resistor, hence the F_o vernier pot inputs and the ΔF inputs via F3 have only ten percent of the effect of the other inputs to the mixer. Since the ΔF ramp is twice the size of the positive-going ramp which feeds amplier A5A1 and which is then fed into F1 inverted, the ΔF ramp sweeps up to twenty percent of the full scale ramp that is applied to F1.

4-99. The output of the tuning voltage controls is the sum of F1, F2 and F3. This output voltage may be a dc voltage for CW operation, or it may be a positive-going ramp for most swept frequency operations or a negative-going ramp for the M1 to M2 sweep if M1 is set at a higher frequency than M2. The exact form of the output is determined by the settings of the various relays and of the various potentiometers. The output portion of Figure 4-10 including relays and mixer amplifier is duplicated as the input to Figure 4-11 so that operation of the marker generator may be more readily understood.

4-100. MARKER GENERATOR - FIGURE 4-11.

4-101. The marker generator produces negative triangular pulses for use as RF markers in the plug-in units, and negative triangular pulses for observation on external equipment via jack J3, the marker jack of the 6600 unit. Input signals to the marker generator come from the tuning voltage controls which are shown in Figure 4-22. Relay contacts and the mixer inverter are shown in Figure 4-23 so that the sources of signal may be more readily discerned. The several ramps and dc voltages are mixed as signals F1, F2, and F3 inputs to the ramp inverter. The inverted output F1 + F2 + F3 is mixed with the original non-inverted signals: F_o pot, F1 pot, and F2 pot. At the inputs of the comparators for F_o, M1 and M2, it will be seen that the ramp inverter feedback resistor R13 has the same value, 19.2 KΩ and so do the input resistors to the comparators from the F_o, M1 and M2 pot signals. Since the sum signal is inverted, the sum of these signals at the input to the comparator will be zero at some point of the frequency change. The two diodes on the input to the comparator connected in reverse polarity and in parallel keep the voltage on the comparator input from varying more than a small fraction of a volt on each side of zero.

4-102. In the generator for the F_o mark, as long as the input to Q3 is positive so that CR3 conducts current, the emitter of Q3 will be held at or above ground potential so that 200 microamps will flow through the 48.7K resistor R24. This same current flows through R18 and the 75,000 ohms resistance gives a drop of 15 volts so that the base of Q1 is at +5 volts. The supply to the emitters of Q1 and Q2 is +15 volts since CR2 has a drop of approximately 5 volts. Q1 is saturated so that approximately 12 milliamps flow through Q1 and hence through the output resistors, R28 and R30. The base of the other input to the differential amplifier Q3 is at ground potential; hence that side of the differential amplifier is cut off and the base of Q2 is at +20 volts and Q2 is cut off. As the drive into the comparator goes toward ground, the current through the input transistor is reduced and the voltage at the base of Q1 rises. This reduces the current through Q1 so that the voltage at the emitter of the output amplifier Q4 is reduced. As the voltage into the input transistor goes negative, the potential at the base of Q1 goes further positive, cutting off Q1, while Q2 starts to conduct before the base of Q1 rises to the same potential as the base of Q2. As the input voltage goes further negative the opposite transistor of the differential amplifier begins to conduct. Q2 goes toward saturation and the current in the output transistors is increased until it reaches the same value that it had when the input voltage was positive. This results in an output voltage change which is a negative triangle into the emitter of Q4.

4-103. The base of Q4 is held at a fixed potential by the marker amplitude potentiometer. When the emitter voltage drops below the base voltage, Q4 conducts and a negative potential appears at the collector. From there it is sent through relay K11 to the RF marker pin of the plug-in unit and via the marker buffer amplifier to the output jack J3. The output is a negative triangle to the plug-in unit and a positive triangle to J3 since it is inverted by the marker buffer amplifier. The amplitude of the pulse is determined by the marker amplitude potentiometer. The peak of the pulse is fixed by the marker generator circuitry. The start of the pulse is determined by the voltage on the base of Q4; hence the amplitude of the pulse may be the full amount that is produced by the output resistors R28 and R30, or it may be of zero amount if the marker amplitude potentiometer output is sufficiently negative.

4-104. The output from the comparator into the output amplifier is a negative pulse for swept frequencies or a dc voltage for CW. The marker amplitude control in marker blanking varies the potential on the base of the output amplifier; hence there is the range of voltage over which the output from the comparator will be detected. When the output of the comparator into the emitter of the output amplifier is less than the base voltage of the output amplifier, current flows and there is a negative voltage output to the marker buffer amplifier and also via relay K11 to the RF marker connection in a plug-in unit. The marker buffer amplifier inverts the negative pulse or negative voltage and applies it to the marker output jack J3 as a positive pulse or voltage.

4-105. The marker blanking circuit cuts off the markers during retrace. The ramp drive signal is -20 volts during frequency sweep, +20 volts during retrace, and zero when there is no trigger or during the momentary delay between end of retrace and start of a new sweep. If the voltage is zero or -20 volts, then Q14 in the marker blanking circuit is cut off since the base is at zero volts. This also cuts off Q13 since there is no positive current to drive the base of Q13; consequently, there is voltage across the marker amplitude potentiometer and the amplitude of the marker pulse may be adjusted. When the ramp drive is +20 volts in retrace, Q14 then is conducting, which means that Q13 is also conducting and is saturated and

there is close to zero potential across the marker amplitude potentiometer, and the output of the potentiometer to the marker generator is -20 volts. This means that the output amplifier never conducts since the emitter can never go below -20 volts. Blanking is also effected by grounding the marker control input to F_o or M1→M2. With these grounds applied, the input to the comparator causes no change in the output since the collector of the input transistor is clamped. The output of the marker generator is selected markers during sweeps. Markers are blanked out during sweep retrace, selected markers also appear for CW operation.

4-106. BLANKING CIRCUIT **A6 A7** FIGURE 4-12.

4-107. The blanking circuit provides positive and negative signals for blanking of an external oscilloscope and provides a negative going ground for blanking the oscillator of the RF Plug-in Unit, when the emitter of A6Q8 is grounded by the RF blanking switch S11. The ramp drive is +20 volts when the tuning signal is in retrace. This voltage turns ON Q8, clamping its collector close to ground. This signal goes to the Plug-in Unit connector, pin 44, via A7. When the ramp drive is -20 volts, for production of the positive turning voltage ramp, current is drawn from the emitter of A6Q9, via A6R25. The collector draws current through R27 and goes to ground potential. This signal is connected to +Scope Blanking connector J14 on the rear panel via J10-5 of A7. It also goes to the emitter of A7Q1, via A7R8. When no current flows in A6Q9 (ramp drive is not negative) current flows through A6R27 into A7R8 and into the emitter of A7Q1, which is clamped to ground by the base of A7Q1. Output voltage at J14 is +10 volts due to voltage divider A6R27 and A7R8. Plus Scope Blanking is +10 volts when there is no forward sweep, ground during forward sweep. The current through A7Q1 during blanking also flows through A7R7, and the base of A7Q2 is clamped to ground. This cuts off current in A7Q2, so the collector goes to -10 volts, which is determined by the voltage divider A7R4 and A7R6. During sweep, current from A7R7 into the base of A7Q2 clamps the collector to ground. The resultant -10 volt blanking signal is connected to -Scope Blank connector J13, on the rear panel.

4-108. Q10 supplies current to the LED sweep indicator so that it is lighted when the positive ramp is being produced.

4-109. M1 DOWN RAMP AMPLIFIER **A4** FIGURE 4-13.

4-110. The Down Ramp Amplifier receives a zero to +10.5 volt ramp from the Ramp Generator, via the Mother Board, A10, at pin 25 of plug A4P1. The current from this ramp, through R76, R77, R78, is mixed with current from -10.5 volts through R81, R82, R83 and feedback current through R79. The resultant current is fed to pin 2 of A4U3. The voltage at the intersection of R85 and R86 thus is a ramp from +10 volts to zero, so that the total current in pin 2 of A4U3 is close to zero. R76 adjusts amplitude; R83 adjusts level. The diodes CR17 and CR18 protect the base-emitter diode of Q21 from excess back voltage.

4-111. The output of this circuit is the basic M1 ramp voltage. It is fed to the M1 pot on A9 via Mother Board, A10, and Control Board, A5.

4-112. SWEEP CONTROL **A9** FIGURE 4-14.

4-113. The Down Ramp (+10V to 0V) produced in Figure 4-13 is fed through relay A5K10 to the junction of R1 and R2 on A9. R1 carries the ramp to pin 1 of R10, the M1 Control Pot. R2 carries the ramp to pin 2 of U1, which inverts the ramp and feeds it to emitter follower Q1. R3 feeds current back so that the output of Q1 is a ramp from -10 volts to zero. Resistors R5, R6 and R8 in series with R9, form an adjustable voltage divider which puts approximately on half volt of the positive ramp on pin 3 of R10. This puts a zero change point about 5 percent away from the pin 3 end of R10. R5 adjusts the position of zero change so that it may coincide with the lowest frequency position of the M1 pot. Adjustment of R12, in series with R11 and R1, controls the amplitude of the negative ramp at pin 1 of R10. This allows an exactly 10 volt sweep to be provided when M1 pot is set at highest frequency. The output of R10 is fed through non-inverting Unity Gain Amplifier U2, to appear as a low impedance negative ramp, M1 and F1 via relay A5K2, in Figure 4-11.

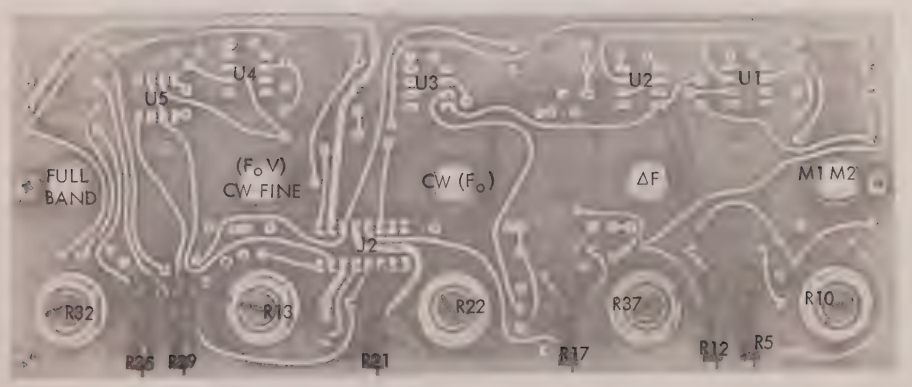
4-114. The Up Ramp produced in Figure 4-9 flows through an identical circuit, containing U4 and U5. R32, which is the M2 control determines amplitude of the output signals, M2 and F1 which go to Figure 4-11. R29 adjusts the minimum frequency voltage. R35 adjusts the maximum frequency voltage, as was done for the M1 control.

4-115. The ΔF Ramp is across R37, the ΔF Control. At this point, the ramp amplitude is 20 volts, from -10 volts to +10 volts. The output of the potentiometer is fed, via relays A5K6 and A5K7, to Figure 4-11, as F3. For use of F3, see paragraphs 4-98 and 4-101.

4-116. F_o and F_o FINE signals are steady voltages adjusted by R22, F_o, and R13, F_o FINE. R13 has approximately +5.3 volts and -5.3 volts across it, with a center tap at ground. R14 and R15 drop ±10.5 volts to these values. Output is F3, to Figure 4-11, via relays A5K6 and A5K7. F_o is controlled by R22, with the high frequency voltage set by R21 and low frequency voltage by R17, as is done for M1 and M2. The steady signal output is filtered by L1 and C7 to reduce possible noise, which would cause frequency modulation.

4-117. VPF GENERATORS **A4** FIGURE 4-15.

4-118. Amplifier A5U1 provides a low impedance source for the zero to +10.5 volt ramp originating in the Ramp Generator. This signal is the tuning control for Full Band Sweep; it is fed to A4U1 when K5 contacts close. Current from this signal through R3 mixes with current from -10.5 volts through R9 and feedback current through R13 to give ground potential at terminal 2 of A4U1. The resultant voltage at terminal 6 of A4U1 sweeps from +9.6 volts to -9.6 volts as Full Band Sweep goes from zero to +10.5 volts. This voltage is connected to pin 5 of plug A4P1 and is fed to the Plug-In Unit via A7. It also is connected to Amplifier A4U2, via R14. The resultant current mixes with current from -10.5 volts, via R1 and feedback current via R16. The resultant voltage



A9

Parts Locations

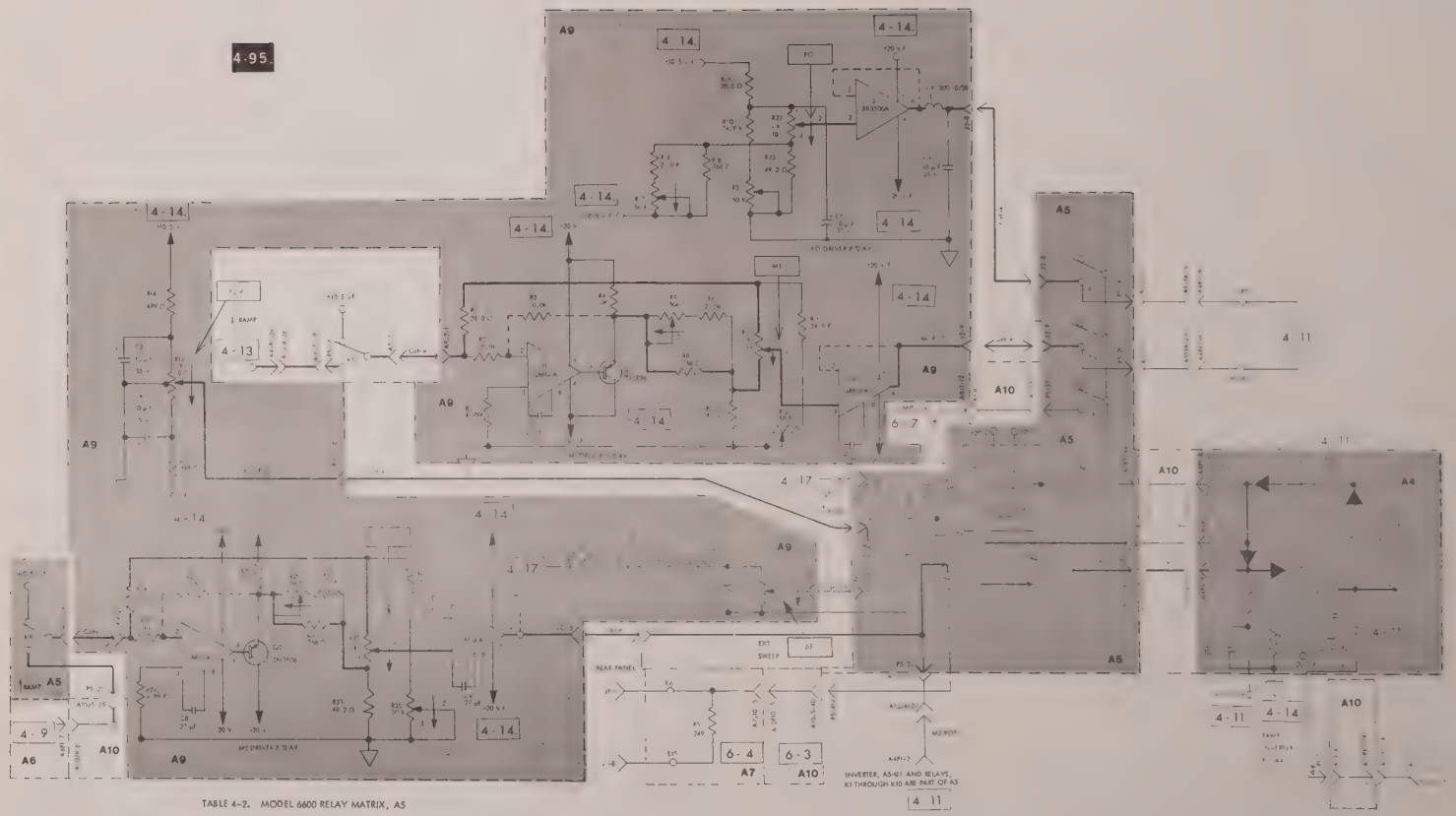


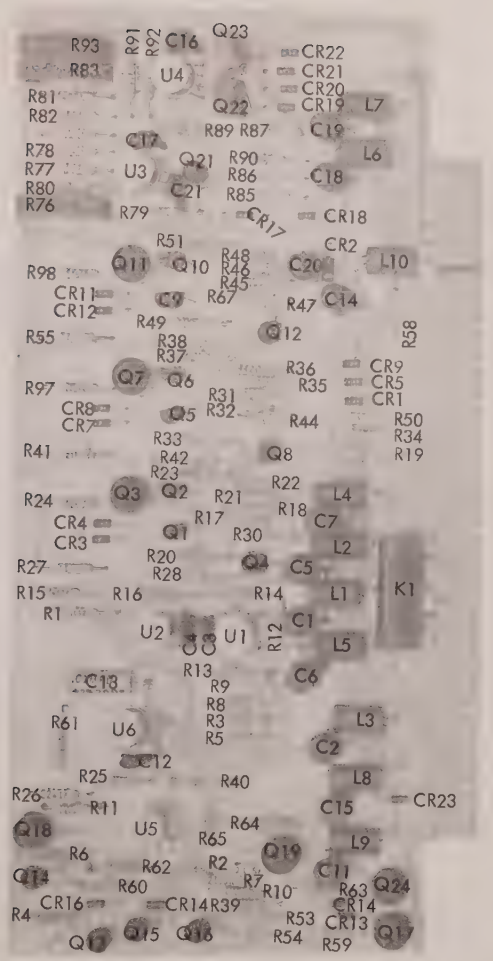
TABLE 4-2. MODEL 6600 RELAY MATRIX, A5

Function \ Relay	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	Fo Marker Off	Sweep Jack Relay	M1-M2 Marker Off	Ramp Gen Off	Filter Relay
M1 - M2		ON						ON	ON	ON						
ΔF	ON					ON	ON					ON				
Fo (CW)	ON											ON	ON	ON	ON	ON
Fo V (CW Fine)	ON						ON					ON	ON	ON	ON	ON
Full Band (FB)					ON											
External Sweep				ON											ON	
External FM	ON			ON				ON				ON	ON		ON	
RF Marker Control											ON					

A9

4 - 10.

Figure 4-10. Tuning Voltages Controls, A9



A4

Parts Locations

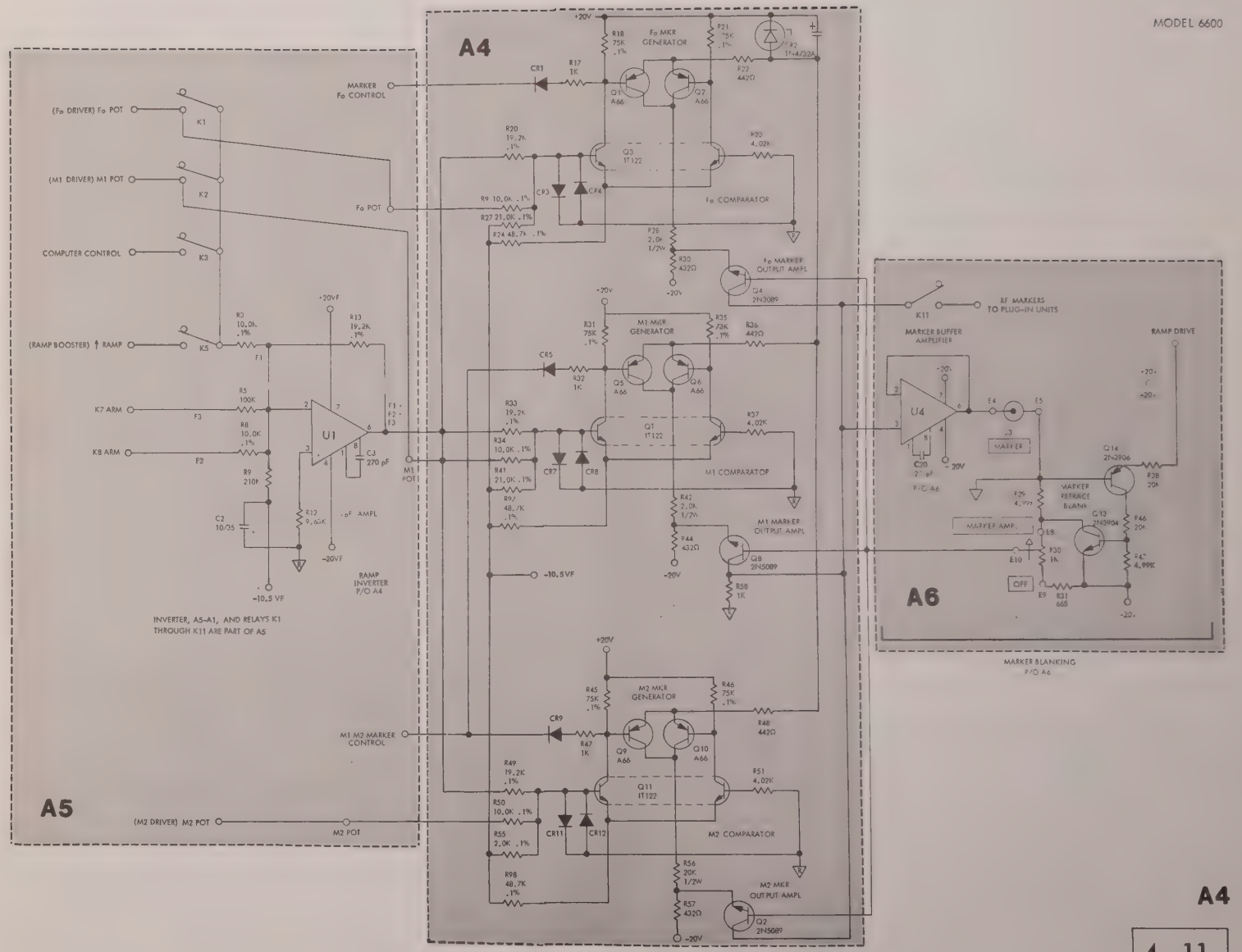


Figure 4-11. Marker Generator, A4

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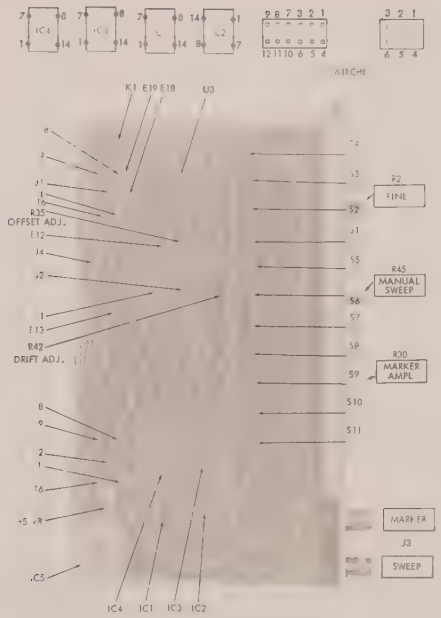
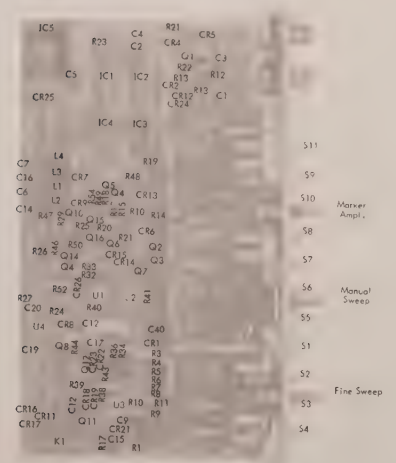
A7

Parts Locations





A6

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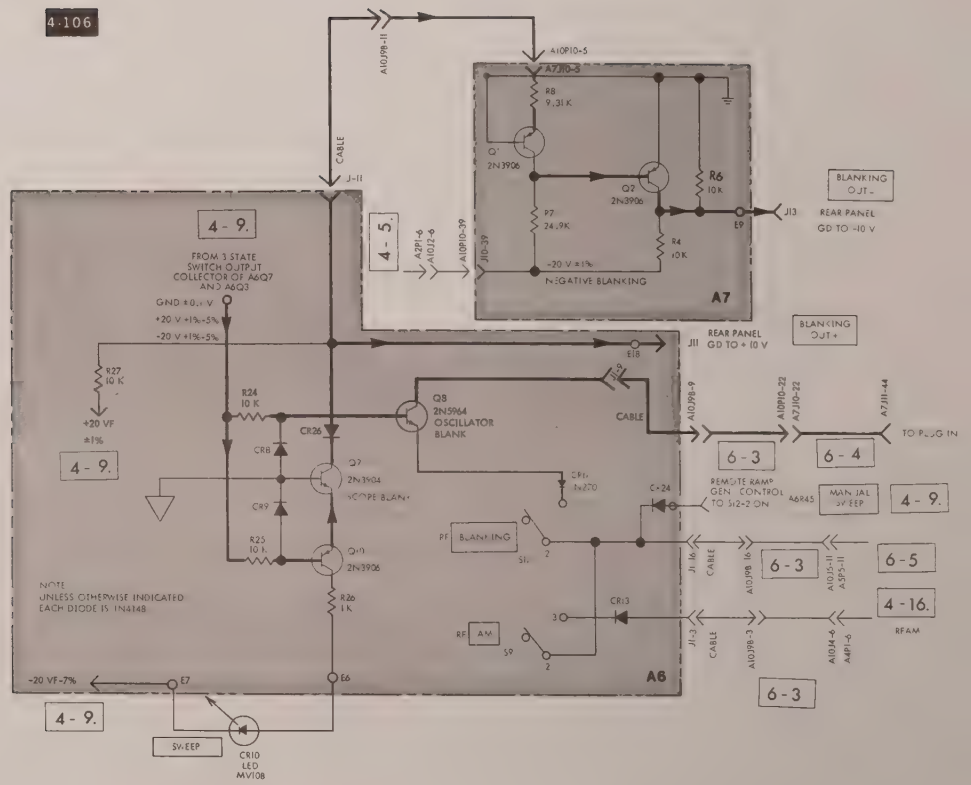
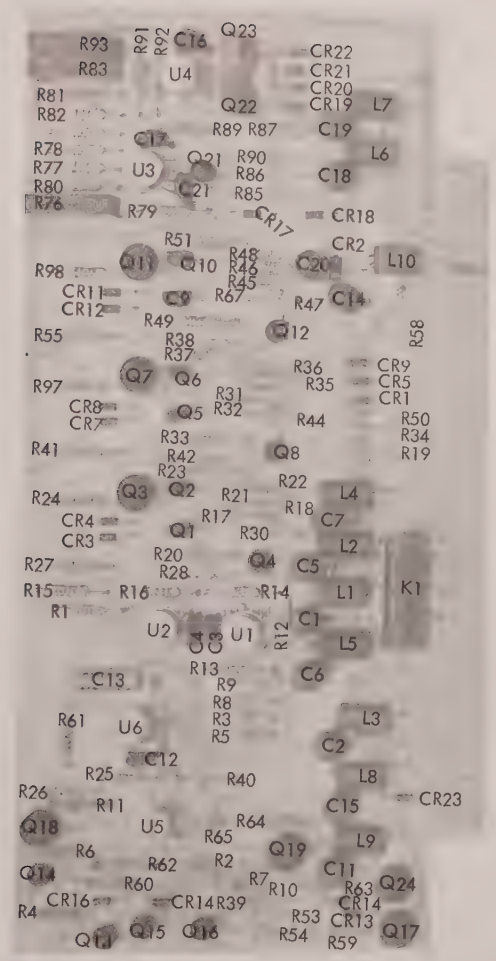


A6

A7

4 - 12.

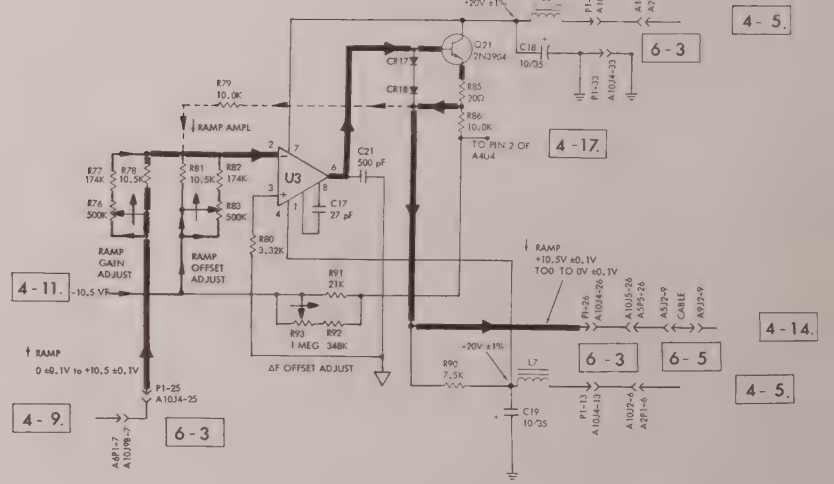
Figure 4-12. Blanking Circuit, A6, A7



A4

Parts Locations

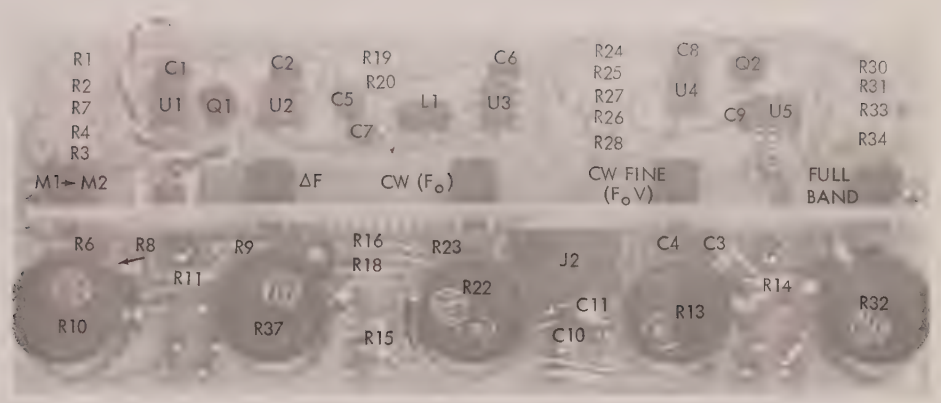
4-109

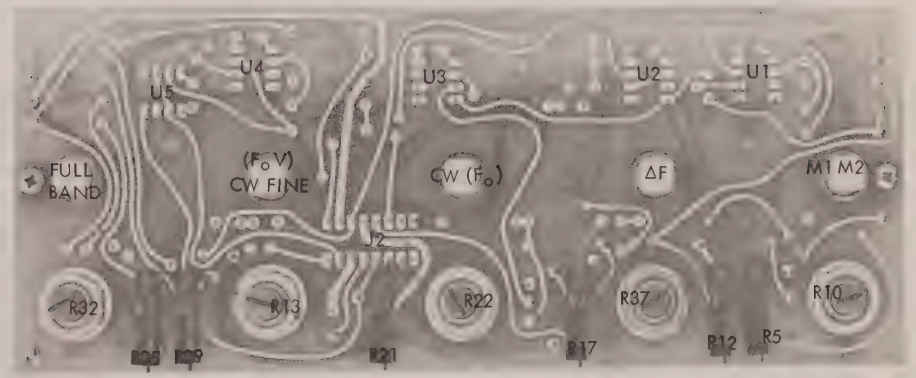


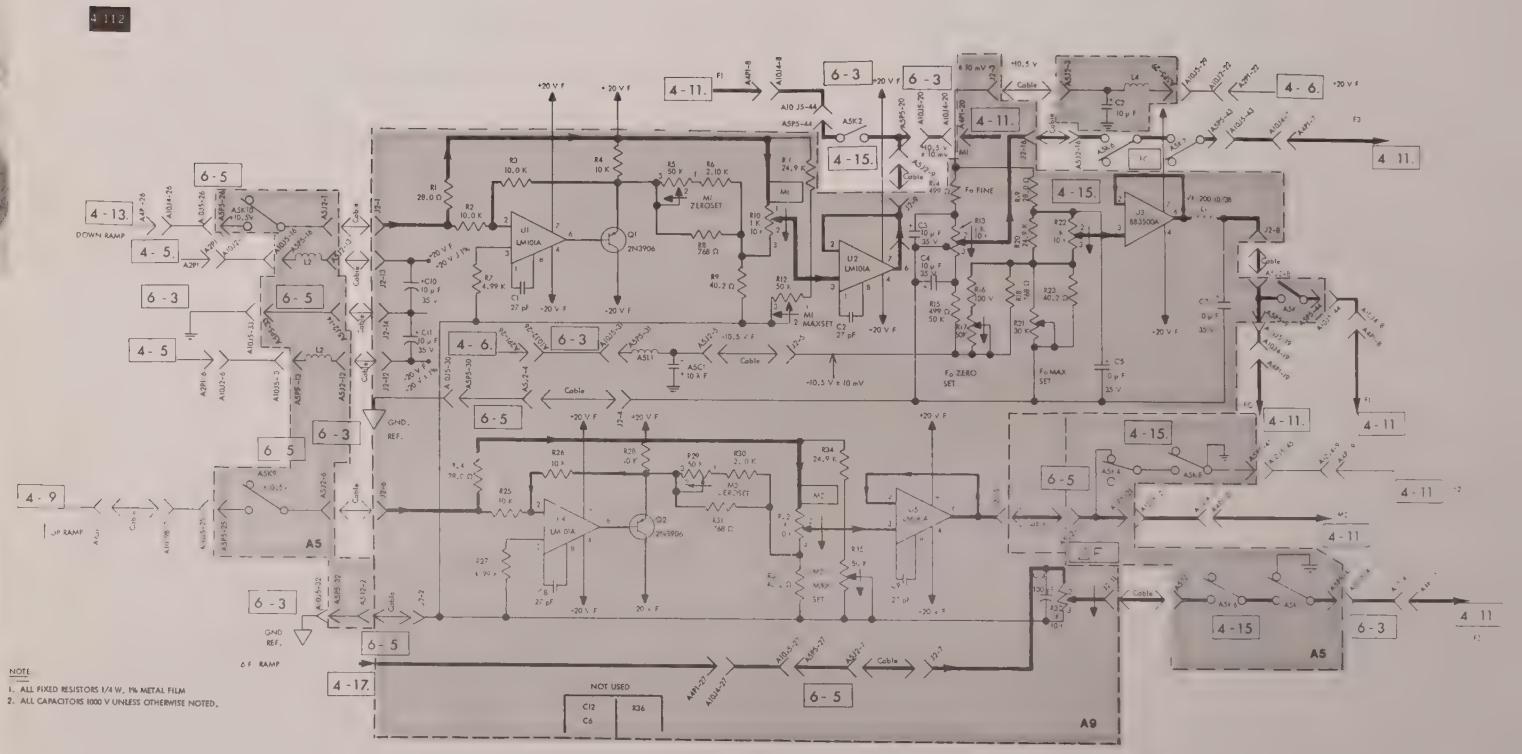
A4

4-13.

Figure 4-13. Down Ramp Amplifier, A4







A9

Parts Locations

A9

4 - 14.

Figure 4-14. Sweep Control, A9

at pin 6 of A4U2 sweeps from zero to +10.0 volts and is fed through pin 47 of plug A4P1 and via A7 to VPF Jack J15 on the Rear Panel.

4-119 SQUARE WAVE GENERATOR **A4** FIGURE 4-16.

4-120. The square wave generator produces a 1 kHz square wave for amplitude modulation of the RF output of the Plug-In Unit. This frequency is adjustable from 950 to 1050 Hz.

4-121. The frequency is determined by the rise and fall times of the integrating amplifier which uses capacitor C6 as the feedback integrating capacitor. When the output of voltage comparator A2 is positive, resistor R4 draws positive current from U2 so that the power supply terminal 7 draws current from +20 volts through resistor R2. This turns on Q6, the multivibrator switch for the positive voltage. Q6 is saturated so that the collector comes up very close to 20 volts positive. Current flows through R35 and R8 into the capacitor C13 of the integrating amplifier circuit. One-third of the available current through R35 flows through R6 and R3, the 1 kHz adjustment pot on the rear panel. The setting of this pot determines the exact amount of current which flows into capacitor C6 and therefore controls the length of time which it takes for the output voltage of the integrating amplifier to drop to -10 volts. This output voltage is balanced against the input voltage from the multivibrator switches, so that when the output voltage is -10 volts and the input voltage from Q6 is at +20 volts, the voltage on terminal 3 of the voltage comparator is at ground potential. With both #2 and #3 terminals of the voltage comparator at ground potential, the output voltage of the voltage comparator U2 switches from positive to negative as the output of the integrating amplifier goes negative. This switches the current drain of the voltage comparator from positive to negative so that Q6 is cut off and Q9 is turned on. The drive into the integrator then becomes -20 volts rather than +20 volts. This causes the output of the integrating amplifier to go in a positive direction at the same rate as it previously went in a negative direction. As the output voltage of the integrating amplifier reaches +10 volts, the input terminal 3 of the voltage comparator goes through zero towards positive and the output terminal 6 goes positive. This causes the current drain of the voltage comparator to go back to positive; hence the negative switch is turned off and the positive switch is turned back on and the cycle is repeated.

4-122. To stop action of the generator, terminal P1-6 is allowed to float. No current is drawn from the base of Q13, so R60 draws approximately one milliampere from the base of Q14. The current into terminal 7 of A5 is shunted to the +20 volt line, hence the positive switch cannot turn on and the multivibrator cannot operate. When the modulation-enable terminal P1-6 is grounded, Q13 draws base current and the input to Q14 is shunted to +20 volts so that Q14 does not conduct and the multivibrator is allowed to oscillate. For external modulation, both the modulation-enable terminal and the external-enable terminals must be grounded. With both these terminals grounded, transistors Q15 and Q16 are both saturated so that the collector of Q16 goes to approximately +20 volts. This applied +20 volts to the junction of CR16 and R2, hence no current is drawn from the base of Q13. R60 then draws current from the base of Q14; Q14 saturates and shorts out the base current for Q18 so that the multivibrator is cut off. At the same time, current is drawn through R54 which saturates Q17 for any external modulation input voltage less than +5 volts. This voltage is determined by the voltage divider formed by R54 and R59 with the diode CR13 in the circuit. Q17 acts as a closed switch to drive the terminal T12 which is called SQUAREWAVE OUT and which also provides external modulation to the plug-in RF unit.

4-123 ΔF RAMP BOOSTER AMPLIFIER **A4** FIGURE 4-17.

4-124. The +10.5 volt to zero volt ramp from the Down Ramp Amplifier is fed through R86 to pin 2 of A4U4. This current is mixed with current through R91, R92, R93, from -10.5 volt and feedback current through R89. The resultant output voltage from the emitter followers Q22 and Q23 is a positive ramp from -10 volts to +10 volts. Level of the ramp is adjusted by R93. Diodes CR19 through CR21 protect the base-emitter diodes of Q22 and Q23 from excess back voltages.

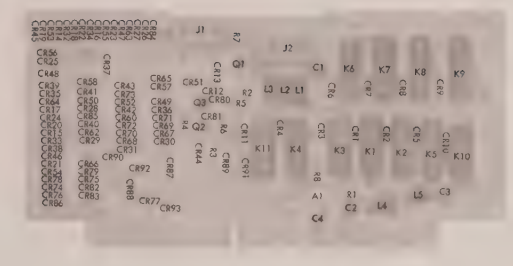
4-125 COMPUTER INPUT **A8** FIGURE 4-18.

4-126. Option 5-1, Computer Interface Circuitry. Drawing No. 907547 shows the circuits which control the Main Frame when the computer is used. Complete isolation of control circuits from the circuits of the Main Frame is provided. The 8-volt supply which is marked +8 Volt Return and +8 Volt in the row of connections at the bottom of the diagram is a totally isolated transformer winding with bridge rectifier and filter. This provides the 5 volts required by the light-emitting diode used to control the internal circuits of the Main Frame. The 8 volts is dropped to 5 volts by the integrated circuit regulator marked IC 2. When any one of the control wires is connected to the input ground wire externally, current flows through the light-emitting diode in the (IS 1 through IS 31) integrated circuit isolators. This allows current to flow in the photo-transistor which in turn drives transistors Q1 through Q31 and clamps the collector of each transistor to ground. Each ground connection for Q1 through Q19 controls a relay on the control board of the Main Frame so that a function is energized. Transistors Q20 through Q31 control a digital to analog converter which converts the digital ground into positive DC voltages which are summed and fed out as D/A OUT on terminal 12 in the line of terminals at the bottom of the drawing. It will be seen from the indicators at the top of the drawing that the voltages may be as small as .01 volts or as large as 8 volts for a single control signal. It is possible to provide over 16 volts output; however, the tuning circuit only uses 0 to 10 volts, so the actual operation of tuning is limited to that amount. It will be seen that the code used is a four-bit decimal code rather than pure binary. The three four-bit groups give a total coverage of 1,000 parts in the code.

4-127. Option 5-2, Tuning Control. Tuning in the CW mode is controlled by grounding wires 1 through 12. The option 5 table gives the voltages which will be applied to the tuning circuits when each one of these wires is grounded. Output frequency is a linear function from minimum selected voltage to maximum selected voltage chosen by the front panel controls of the Main Frame or by the computer circuits which override the actual manual controls. The difference between output frequency and the minimum front panel chosen frequency is directly proportional to the voltage which is the sum of the selected voltages from terminals 1 through 12. If the selected voltage is 10.0 volts, then the output frequency is the maximum frequency of the band chosen.

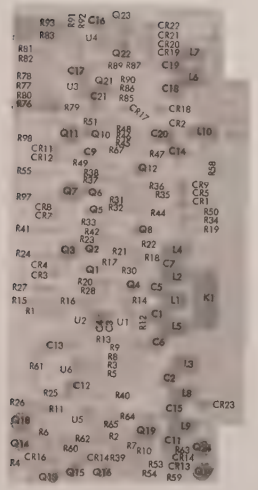
4-128 CALIBRATION PROCEDURE.

4-129. A complete calibration procedure for the Model 6600 is shown in Table 4-3. This procedure may be used to check and adjust any output voltage of the Model 6600. It must be realized, however, that any out-of-calibration voltage may be out of calibration because the voltage supplied to its regulator is out of calibration. Check supply and reference voltages to any regulator before adjusting the voltage control potentiometer.



A5

Parts Locations



A4

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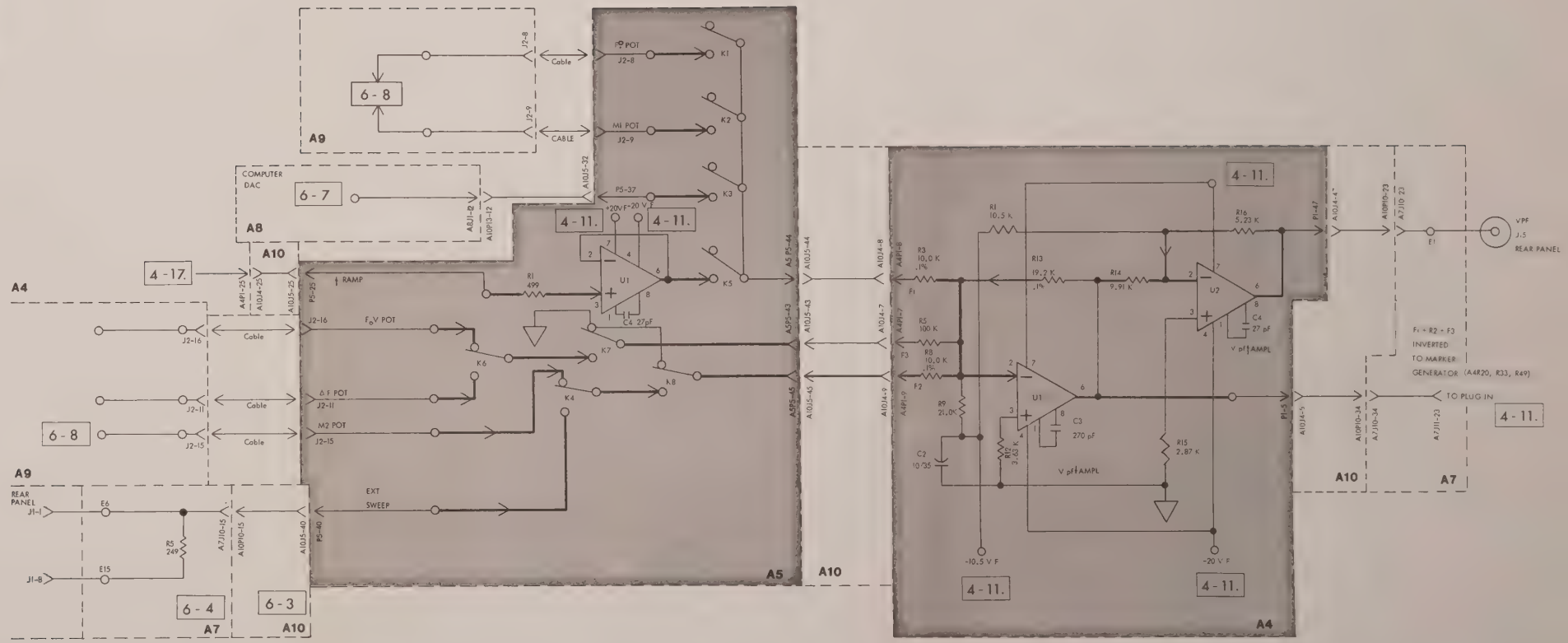
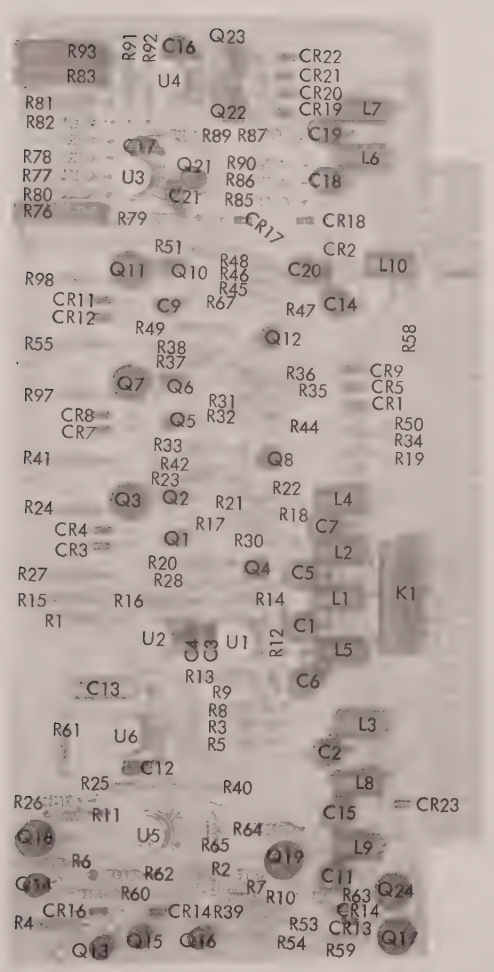


A4

A5

4 - 15.

Figure 4-15. VPF Generator, A4, A5



A4

Parts Locations

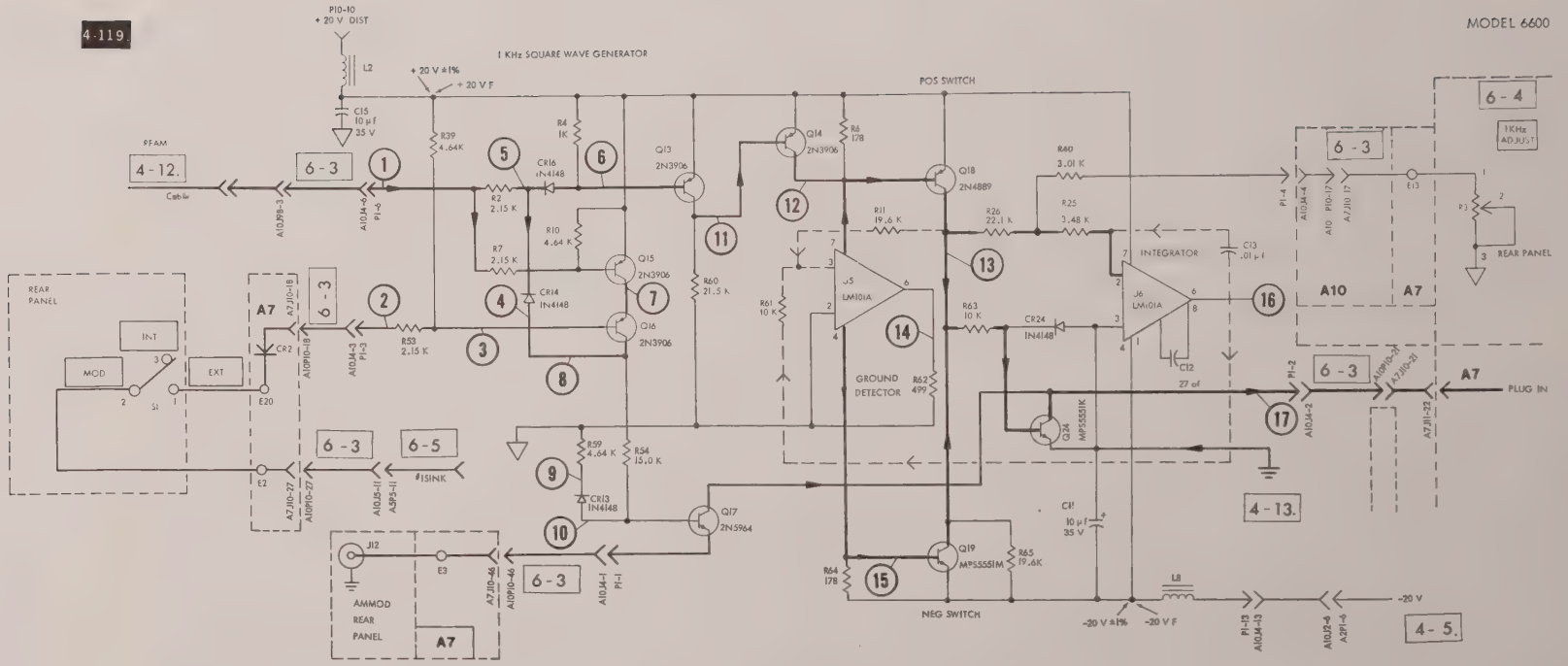
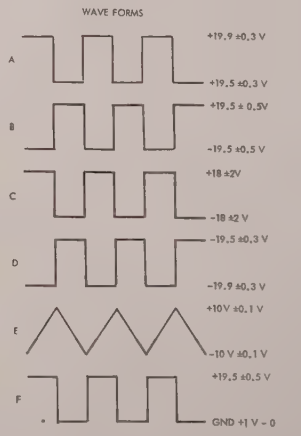


TABLE 4-3. MOTHER BOARD, A4, VOLTAGE OR WAVE FORM FOR CONTROL SETTINGS SHOWN

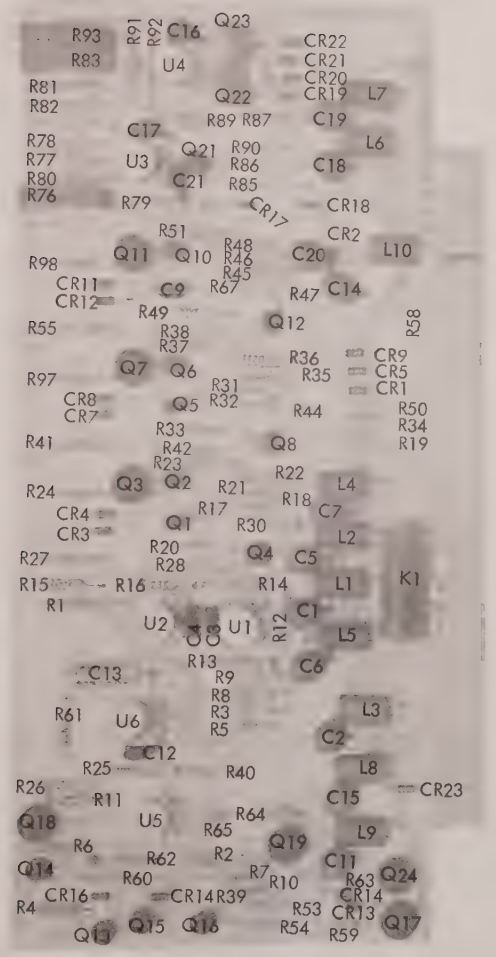
Schematic Test Point	ON EXT	OFF INT	ON INT	Modulation Switch External Switch
1	+0.6V	+20.0V	+0.6V	Notes: Unspecified tolerances are ±3% or ±0.3V, whichever is larger.
2	+0.6V	+20.0V	+20.0V	
3	+19.3V	+20.0V	+20.0V	
4	+19.3V	+20.0V	+19.3V	
5	+19.4V	+19.9V	+18.7V	
6	+19.9V	+20.0V	+19.3V	
7	+20.0V	+20.0V	+20.0V	
8	+20.0V	0V	-0.5V	
9	+4.6V	0V	0V	
10	+5.2V	0V	-0.5V	
11	+19.2V	+19.2V	+19.95V	
12	+19.9V	+19.9V	A	
13	-1.95V	-1.95V	B	
14	+9.8V	+9.8V	C	
15	-19.9V	-19.9V	D	
16	+20V	+20V	E	
17	0 to +20 V, AC	0 to +20V Floating	F	



A4

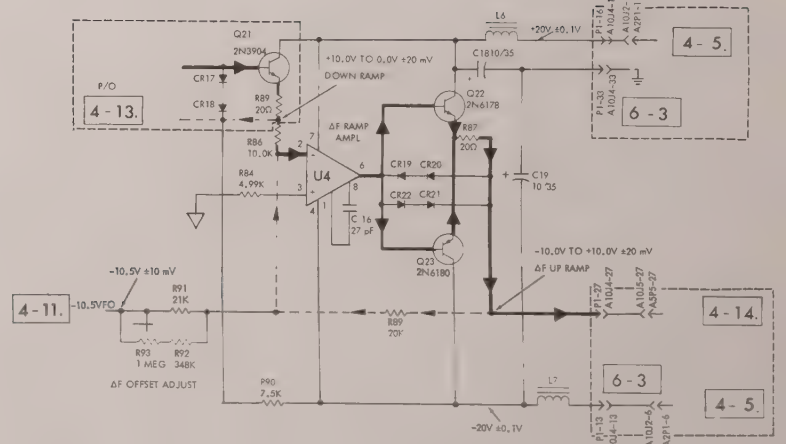
4 - 16.

Figure 4-16. Signal Wave Generator, A4



A4

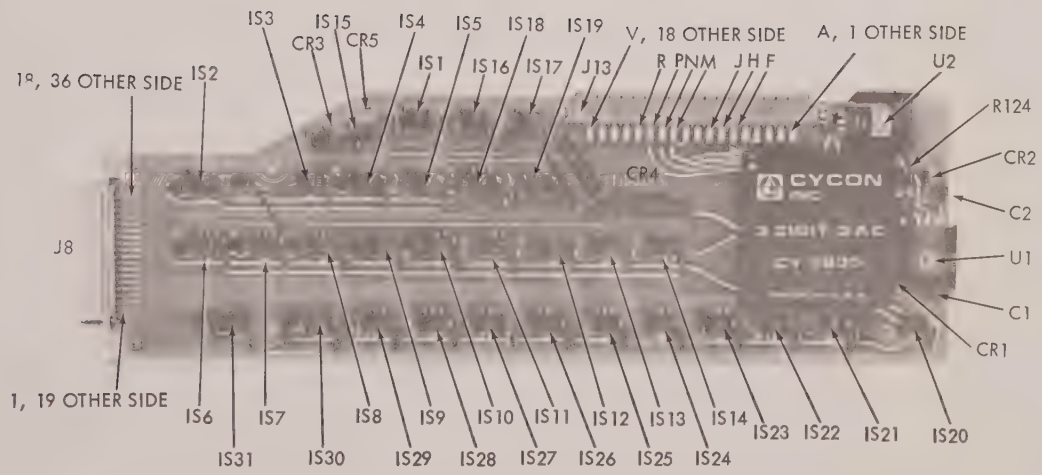
Parts Locations



A4

4 - 17.

Figure 4-17. ΔF Ramp Booster Amplifier

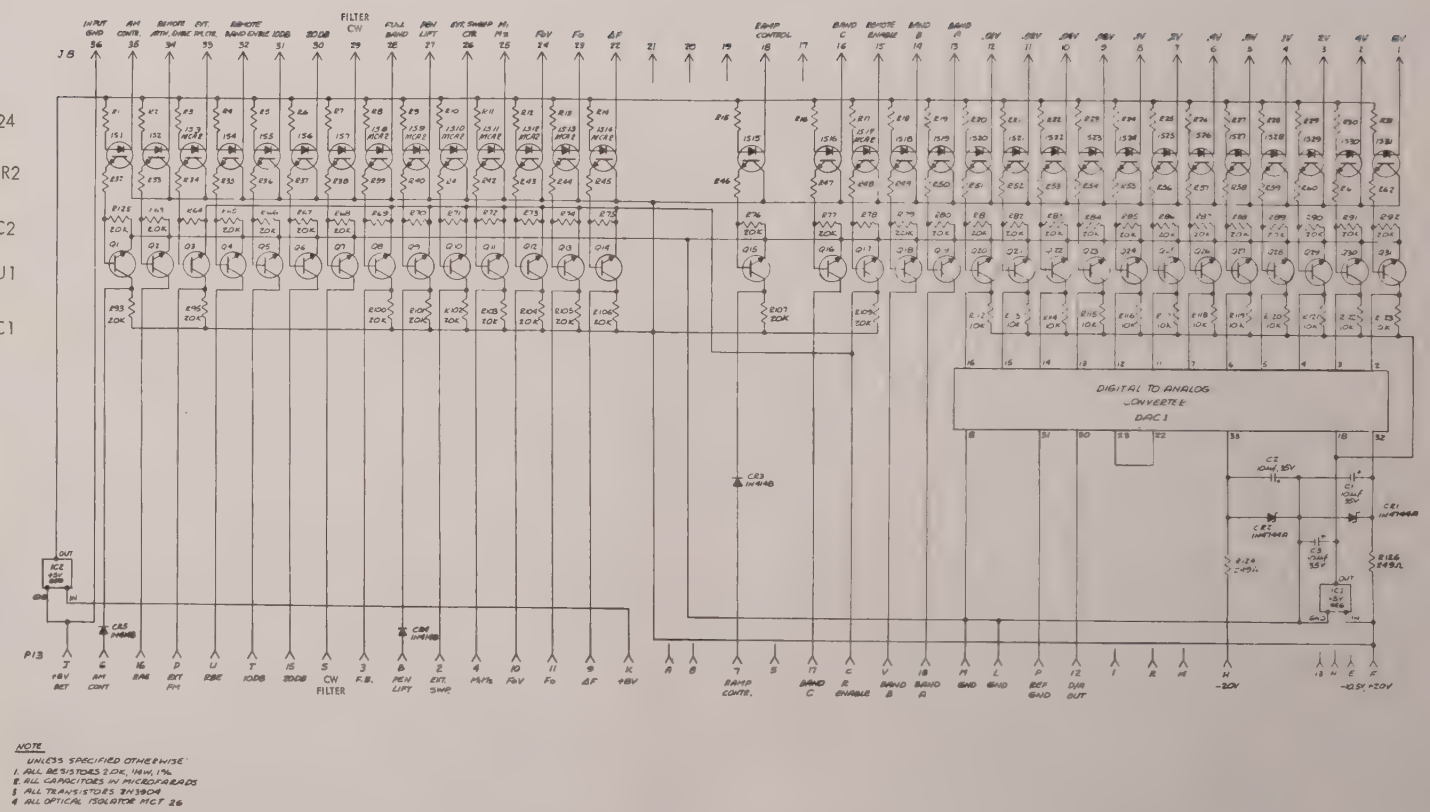


ORIENTATION MARK

IS, AS MOUNTED ABOVE

A8

Parts Locations



NOTE
UNLESS SPECIFIED OTHERWISE
1. ALL RESISTORS 2.0K, 1/8W, 1%
2. ALL CAPACITORS IN MICROFARADS
3. ALL TRANSISTORS 2N3904
4. ALL OPTICAL ISOLATOR MCT 26

A8

4 -18.

Figure 4-18. Computer Input, A8

TABLE 4-3. ALIGNMENT PROCEDURE, MODEL 6600

1. GENERAL

This alignment procedure prepares a Model 6600 Sweep Oscillator to meet all the requirements of Model 6600 specifications. Refer to Table 1-1, Specifications.

2. REQUIREMENTS

2.1 FUNCTIONAL REQUIREMENTS - The Model 6600 Sweep Oscillator shall meet all the requirements specified in Table 1-1.

2.2 TEST CONDITIONS - All tests shall be conducted at room ambient conditions. Room ambient is defined as a temperature between 16°C and 35°C, (62-95°F), relative humidity less than 90% and barometric pressure between 28 and 32 inches of mercury.

2.3 FAILURES - All failures discovered or occurring during test shall be corrected before testing is continued. Failures affecting tests that have already been completed shall cause these tests to be repeated. After the instrument has been tested and calibrated no component shall be changed or adjustment made unless the relevant tests specified in section 3.3 are repeated.

2.4 MEASUREMENTS - All performance measurements shall be made with instruments whose accuracy has been certified by an approved calibration agency.

2.4.1 APPROVED TEST EQUIPMENT

Refer to Table 2-4, Recommended Test Equipment.

2.4.2 MEASUREMENT TECHNIQUES

a. All voltage adjustments are made at no load except where indicated otherwise.

b. All noise and ripple measurements are made with a scope bandwidth of 10 kHz under various line and load conditions.

c. Line regulation is checked under full load.

d. Load regulation is checked at nominal line voltage (117V).

e. When changing voltages, push No Load Button, then select desired voltage, current and polarity. Then push the desired load button.

3.1 EXAMINATION OF INSTRUMENT

Prior to performing any functional tests, the instrument shall be visually inspected. Any apparent discrepancies or errors shall be corrected before testing is started. Inspect to determine that all printed circuit boards are correctly installed and that no parts are obviously missing. It is imperative that calibration technicians performing this procedure for the first time read this DC Test and Calibration procedure thoroughly and completely before beginning the functional procedure.

3.1.1 PROCEDURAL NOTES

a. All ripple measurements are peak to peak.

3.2 FUNCTIONAL PROCEDURE

3.2.1 PRELIMINARY CHECKS

NOTE: When results of these procedures do not conform to specifications in Table 1-1, and adjustments do not correct the problems or are not described, go to Troubleshooting Procedures in this section.

TABLE 4-3. ALIGNMENT PROCEDURE, MODEL 6600 (CONT.)

3.2.1.2 PRELIMINARY CONNECTIONS

CAUTION

Power MUST NOT be applied to the 6600 before these connections have been made.

a. Insert 6602 into 6600 Main Frame and close latch.

b. Connect voltmeter to red TP and black REF ground terminals on 6602 panel.

3.2.2 LOW VOLTAGE REGULATOR (A2) BOARD, SINGER P/N 952347

a. Press no load, +, 20 V and adjust A2R46 to give +20.000 V ± .020 V.

b. Press 1 amp., +, 20, full load. The indication of the +20 V regulator should not drop more than .200 V.

c. Press no load, -, 20 on 6602. Adjust A2R41 to give +20.000 V ± .020 V.

d. Press 1 amp., -, 20, full load on 6602. The reading of the -20 V regulator should not drop more than .2 V.

e. Press no load, +, 10.5 on 6602 and adjust A2R10 (after 5 minutes from turn on) to give +10.503 V ± .001 V.

f. Press 50 mA, +, 10.5 full load on 6602. Indication of the +10.5 V regulator should not drop more than .016V.

g. Press no load, -, 10.5 V and adjust A2R22 (after 5 minutes from power turn on) to give -10.503 V ± .001 V.

h. Press 50 mA, -, 10.5 V, full load. Indication should not drop more than .016 V.

i. Pre-Test is complete.

3.3 TEST AND CALIBRATION PROCEDURE

a. Depress F_o FINE pushbutton.

b. Connect voltmeter to J4 - 20 on Mother Board.

c. Align M1 Pointer @ 100% dial.

(Always approach scale calibration lines in a CW direction to prevent back-lash error.) Slip the gear mounted to the dial drive to permit turning the pot gear without moving the mechanism, so that the voltmeter reads +10.000 ± .005 V.

Tighten set screw and doublecheck reading by turning the control CCW one turn and then repeating step e as necessary until the calibration voltage is reached.

d. Turn M1 control fully CCW and then align pointer @ 0% dial. Adjust R5 to obtain a voltmeter reading 0.000 V ± .005 V.

e. Turn M1 control CW again and align M1 pointer @ 100% dial. The voltmeter reading should be 10,000 V ± .005. Adjust the voltage using R12 if necessary.

f. Connect the voltmeter to J4 - 21 on Mother Board. Align M2 pointer with the high end calibration line and repeat steps c thru e using R29 @ 0% dial and R35 @ 100% dial.

g. Connect the voltmeter to J4 - 19 on Mother Board. Align F_o pointer @ 100% dial and repeat steps c thru e using R17 @ 0% dial and R21 @ 100% dial.

TABLE 4-3. ALIGNMENT PROCEDURE, MODEL 6600 (CONT.)

h. Connect the voltmeter to J4 - 7 on Mother Board. Align F_o FINE pointer with the F_o FINE "0" calibration line (in the center of the F_o scale sector). Slip the gear mounted on the dial drive to permit turning the pot gear without moving the dial mechanism, so that the voltmeter reads 0 V ± 3 mV.

Tighten set screw and doublecheck reading by turning the control CCW one turn and then repeating if necessary until the calibration voltage is reached.

i. Turn ΔF control fully CCW. The ΔF pointer should line up with 0% dial. If it does not, slip the gear mounted on the dial drive to permit turning the pot to its stop, without moving the dial mechanism, so that the pot stops the mechanism exactly at the low end ΔF calibration line. If an adjustment was required, doublecheck reading by turning the control CW one turn and then repeating if necessary to properly calibrate the stop point.

TABLE 1. POT BOARD ADJUSTMENTS

Pointer	Adjustment @ 100% Dial	@ 0% Dial
M1	R12	R5
F_o	R21	R17
M2	R35	R29
	POT BOARD	

3.4 RAMP GENERATOR PRE-TEST

3.4.1 PRELIMINARY STEPS

a. Check lamp sockets for shorts.

b. Connect ramp generator assembly (952351, A6) via two extension cables to the mating connectors on the Mother Board in a mainframe containing a calibrated low voltage regulator board (952347, A2), and a modulation board (952349, A4).

c. Connect the SWEEP output jack on front panel of the 6600 to the vertical input of the scope. Set vertical sensitivity to 5 V/division, D.C. coupled.

d. Connect the + BLANKING output jack on rear panel of the 6600 to TRIGGER input of scope. Set scope to EXT + SLOPE and AUTO trigger and sweep time to 2 msec/division.

e. On the 6600 front panel, depress and turn fully CCW the MANUAL SWEEP CONTROL. Depress INT trigger, .01 SEC. sweep time. Turn VARIABLE sweep control fully CCW. On rear panel turn AM MOD switch to INT.

f. Observe that sweep wave form is per Fig. 1. Note linearity of sweep time.

g. Depress .10 SEC sweep time on 6600 and 20 msec/division on scope and observe sweep wave form per Fig. 1.

h. Depress 1.0 SEC sweep time on 6600 and .2 sec/division on scope and observe sweep wave form per Fig. 1..

i. Depress 10 SEC. sweep time on 6600 and 2 sec/division on scope and observe wave form per Fig. 1.

j. Depress .01 SEC sweep time on 6600 and 50 msec/division on scope, turn VARIABLE sweep control fully clockwise. Observe 130 - 250 msec sweep time.

TABLE 4-3. ALIGNMENT PROCEDURE, MODEL 6600 (CONT.)

3.4.2. SWEEP TRIGGER AND SYNC OPERATION CHECK

a. Connect SWEEP output to horizontal input of the scope, set scope on EXT sweep and 1 volt/division. Center trace on scope.

b. Turn VARIABLE sweep control fully CCW. Depress 10 SEC sweep time and EXT trigger. Press EXT/SINGLE pushbutton. Assure that sweep is initiated. Press pushbutton again. Sweep should retrace to start. Press pushbutton again to initiate sweep.

c. Connect a 60 Hz source to the vertical input of scope. Depress the LINE trigger and .10 SEC sweep time and turn the VARIABLE sweep control. The 60 Hz wave on the scope should remain synchronized to the sweep.

d. Depress INT trigger pushbutton. The 60 Hz waveform should run free.

e. Connect the SWEEP jack to the vertical input of scope, set vertical sensitivity to 50 MV/CM and set to internal sweep, AUTO INT trigger. Depress EXT trigger on 6600, 10 SEC sweep time and turn VARIABLE sweep fully clockwise. Adjust A6R42 to give very slow upward drift which resets no more than once per 3 seconds.

f. Depress .01 SEC sweep time and adjust A6R35 to give very slow upward drift which resets no more than once per 3 seconds.

g. Repeat 3.5.3 e and f until both are satisfactory.

3.4.3 SWEEP/BLANKING WAVEFORM

a. Connect SWEEP output to the vertical input of scope. Set scope to external, positive trigger.

b. Connect through a BNC "T" the + BLANKING output (rear panel) to the EXT TRIGGER INPUT of the scope and gate input of a CMC 605A counter set to measure time period. Adjust counter so that it gates between a negative going edge and a positive going edge.

c. Observe the sweep wave form as in Figure 1, and measure each time (T Number) on counter. They should match Table 2, ±10% for each setting of sweep timing, with variable control full CCW.

d. Connect RF BLANK output of 6600% to vertical input of scope and as in 3.5.3b.

e. Press RF BLANKING pushbutton and observe the blanking wave form in Figure 2.

f. Connect the + BLANKING output (rear panel) to the vertical input of the scope. Observe the wave form in Figure 3.

g. Connect the - BLANKING output (rear panel) to the vertical input of the scope. Observe the wave form in Figure 4.

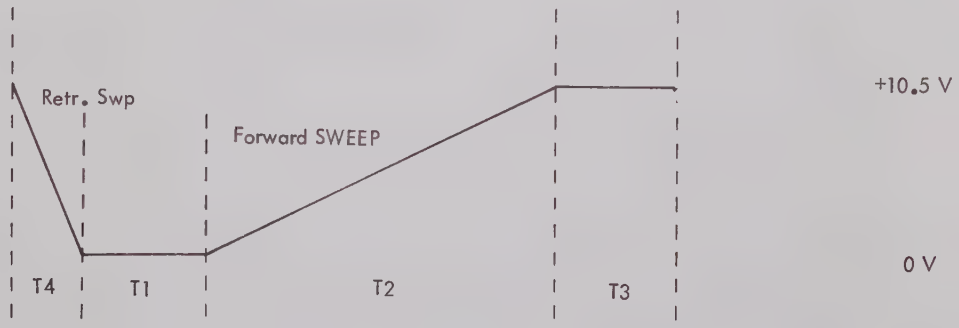


FIGURE 1

TABLE 4-3. ALIGNMENT PROCEDURE, MODEL 6600 (CONT.)

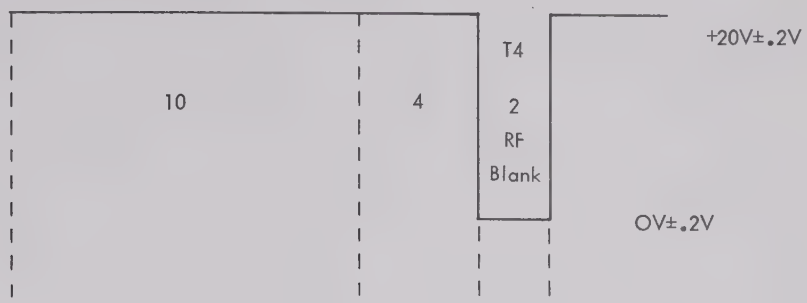


FIGURE 2

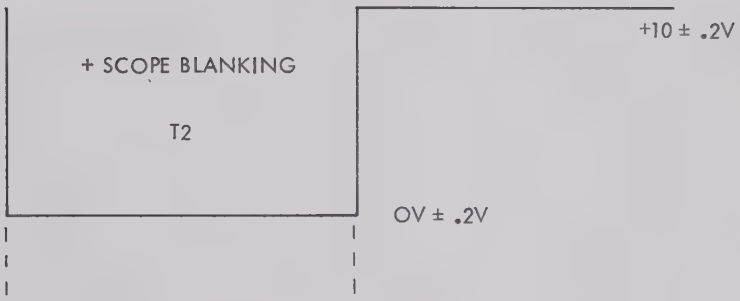


FIGURE 3

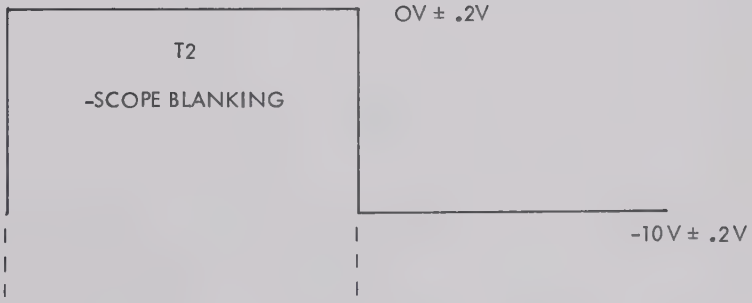


FIGURE 2

TABLE 4-3. ALIGNMENT PROCEDURE, MODEL 6600 (CONT.)

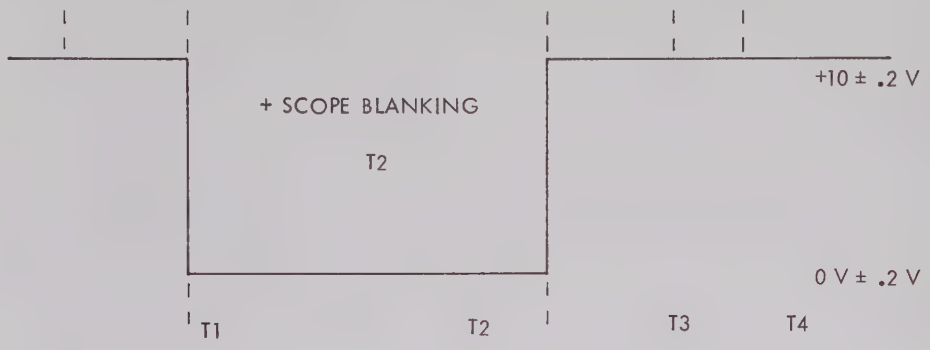


FIGURE 3

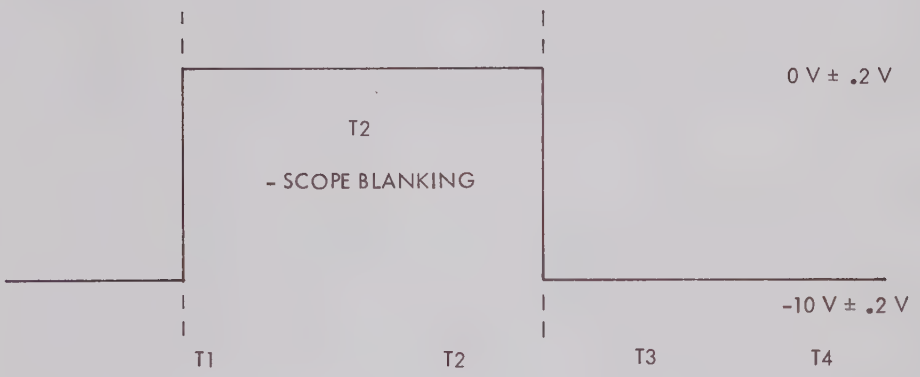


FIGURE 4

TABLE 2

Sweep Setting	T1	T2	T3	T4
.10 sec	4 msec	9.5 - 10.5 msec	4	2 msec
.1 sec	4 msec	95 - 105 msec	4	10 msec
1 sec	4 msec	.95 - 1.05 msec	4 msec	100 msec
10 sec	200 msec	9.5 - 10.5 msec	200 msec	1 sec

MEASURE PERIODS WITH COUNTER

TABLE 4-3. ALIGNMENT PROCEDURE, MODEL 6600 (CONT.)

3.4.4. CONCLUDING STEPS

Disconnect ramp generator from extension cables and return to its socket in main frame.

3.5 MODULATION BOARD (952349, A4)

3.5.1 DOWN RAMP CALIBRATION

a. Remove Control Board A5 and Ramp Generator Board A6.

b. Connect DVM to PIN J4 - 26 on Mother Board. Connect a jumper from J4 - 25 to ground. Adjust R83 until meter reading of 10.500 V ± .005V is obtained.

c. Disconnect jumper from ground and connect between J4 - 25 and +10.5 V. Adjust R76 until a reading of 0.00 V ± .005 V is obtained.

3.5.2 ΔF RAMP CALIBRATION

a. Having performed 3.5.1, connect a DVM to PIN J4 - 27 and note voltage reading (approximately -10.5 V).

b. Disconnect jumper from +10.5 V and connect between ground and J4 - 25. Note voltage reading (approximately -10.5 V).

c. 1) Take the difference of the absolute value of the two readings.
2) Divide the result by two and
3) Add to smaller voltage.

d. Adjust R93 to give this reading halfway between the previous two readings.

e. Disconnect jumper from ground and connect between +10.5 and J4 - 25. Reading should be the same as in 3.5.2 d. If not, repeat 3.5.2 c.

3.5.3 VPF DOWN RAMP CHECK

a. Connect the DVM to J4 - 5 (VPF down ramp). Connect a jumper from J4 - 8 to ground. Also connect a jumper from J4 - 9 to ground. The reading on the DVM should be +9.600 V ± .050.

b. Disconnect the jumper from J4 - 8 and connect between J4 - 8 and +10.5 V. Reading should be -10.56 V ± .050.

c. Disconnect the jumper from +10.5 V and connect to ground. Disconnect the jumper from J4 - 9 and connect between J4 - 9 and +10.5 V. Reading should be -10.56 V ± .050 V.

d. Connect the DVM to J4 - 47. The reading should be 11.025 V ±0.100 V.

e. Disconnect the jumper from J4 - 9 and connect J4 - 9 to ground. The reading should be 0.00 V ± .1 V.

3.5.4 VPF OUTPUT CHECK

a. Disconnect all jumpers.

b. Set controls on CW.

c. Set F_o at 10 on linear (0-100) scale.

d. Measure DC voltage at VPF output. It should be 1.0 ±0.1 volts.

e. Set F_o at 100 on linear (0-100) scale.

f. Measure DC voltage at VPF output. It should be 10.00 ± 0.1 volts.

TABLE 4-3. ALIGNMENT PROCEDURE, MODEL 6600 (CONT.)

3.5.5 MARKER AMPLITUDE AND POSITION CHECK

a. Reinsert and connect ramp generator board A6, and control board A5.

b. Connect sweep output to the external horizontal input of the scope and connect the marker output to the vertical input of the scope. Set the scope for X10 ext. sweep. Center the trace and adjust the horizontal gain to extend the trace to the graticule limits.

c. Push the FULL BAND pushbutton and rotate MARKER AMP control full CCW to CW, and observe that amplitude of F_o, M1, M2 markers is 0 to 5V ± .5V.

d. Adjust markers to coincidence near 100% point of dial. Pointers of dial should be within 0.5% of fully scale of each other.

e. Voltages on pins 19, 20, 21 on A4 should be within .05 V of each other.

f. Repeat 3.5.5 d near 0% of dial.

g. Adjust M1, F_o, M2 markers into the 0 to 10% range of the sweep. Change horizontal gain of scope from X10 to X1 (1 V/div. to 0.1/div.). This should expand the lefthand 10% of sweep to full scale. Observe that the base width of each marker is approximately one division but less than two divisions.

3.5.6 SQUARE WAVE MODULATION CHECK

a. With the 6602 blanking output connected to the vertical input of the scope and tee'd to the gate of the counter -- set to measure frequency. Set AM switch (rear panel) to INT. On 6600 release RF blanking and depress RF AM.

b. Adjust the frequency control (rear panel) and observe a square wave which varies from 950 to 1050 Hz as checked on counter.

c. The duty cycle of the square wave should be 50% ± 5% throughout the frequency range.

d. The amplitude of the square wave should be from 0V ± .2V to 10V ± .5V.

e. Set the AM switch (rear panel) to EXT and connect a square wave generator to the EXT AM input (rear panel) and determine that a plus ten volt square wave from the generator will obtain a +10 V excursion of the blanking wave form displayed on scope.

3.6 LOW VOLTAGE REGULATORS

3.6.1 PRELIMINARY STEPS

a. Check that LV power supply P.C. board (#952347, A2) and ±60V Reg. P.C. board (#952348, A3) are properly installed in the main frame.

b. Connect DVM leads to the red TP and black REF GND terminals on the 6602 panel.

3.6.2 CALIBRATION CHECK

3.6.2.1 CALIBRATION OF +20V REGULATOR

a. On Model 6602, push +20V, 1A and NO LOAD. Adjust A2R46 to obtain +20.000V ± .020V.

b. Set the load switch to full load and vary the line voltage from 105 - 125 VAC. Note and record the voltage variation on the voltmeter.

c. Set the line voltage to 117 VAC. Then, alternate the load switch between no load and full load and note and record the voltage variation on the voltmeter.

d. Note and record the max P-P ripple and noise on the scope while adjusting line and load randomly to obtain worst case.

TABLE 4-3. ALIGNMENT PROCEDURE, MODEL 6600 (CONT.)

3.6.2.2 -20 V REGULATOR

a. On Model 6602, select -20 V, 1A, and no load.

b. Adjust A2R41 to obtain -20.000 ± .020 V.

c. Repeat steps 3.6.2.1 c and d, and record voltage variations.

3.6.2.3 +10.5 V REGULATOR

a. On Model 6602, select +10.5 V, 50 mA, no load.

b. Adjust A2R10 to obtain +10.503 V ± .001V.

c. Repeat steps 3.6.2.1 c and d , and record voltage variations.

3.6.2.4 -10.5 V REGULATOR

a. On 6602, select -10.5 V, 50 mA, and no load.

b. Adjust A2R22 to obtain -10.503 V ± .001V.

c. Repeat steps 3.6.2.1 c and d, and record voltage variations.

3.6.2.5 +62 V REGULATOR

a. On 6602, select +62 V, 300 mA, and no load.

b. Note and record the voltage on voltmeter

c. Repeat steps 3.6.2.1 b through d, and record voltage variations.

3.6.2.6 -62 V REGULATOR

a. On 6602, select -62 V, 300 mA, and half load.

b. Note and record the voltage or voltmeter.

c. Repeat steps 3.6.2.1 b through d and record voltage variations.

3.6.2.7 + PROGRAM REGULATOR HIGH PROGRAM

a. On 6602 select no load, 300 mA, +, and program; with pot on 6602 , adjust voltage to +59.00 V ± .05 V.

b. Repeat steps 3.6.2.1 c and d.

3.6.2.8 + PROGRAM REGULATOR LOW PROGRAM

a. On 6602 select no load, 1A, +, and program; with pot on 6602 adjust voltage to 18.00 V ± .05 V.

b. Repeat steps 3.6.2.1 b through d.

3.6.2.9 - PROGRAM REGULATOR

a. On 6602 select no load, 300 mA, -, and program; with pot on 6602 adjust voltage to -59.00 V ± .05 V.

b. Repeat steps 3.6.2.1 b through d.

3.6.2.10

a. On 6602 select no load, 2A, -, and program; with pot on 6602 adjust to 11.00 V ± .05 V.

b. Repeat steps 3.6.2.1 b through d.

TABLE 4-3. ALIGNMENT PROCEDURE, MODEL 6600 (CONT.)

3.6.2.11 PLUS PROGRAM REGULATOR

a. Remove 6602. On Mother Board attach a DVM between the terminal marked +P and GND. With a jumper, short ther terminal to GND. Remove jumper and read DVM. The reading should be 0.000 V ±0.005 V.

3.6.2.12 MINUS PROGRAM REGULATOR

a. Remove 6602 . On Mother Board attach a DVM between the terminal marked -P and GND. With a jumper, short the terminal to GND. Remove jumper and read DVM. The reading should be 0.000 V ± .005 V.

b. Replace 6602.

3.7 CONTROL BOARD (#952350, A5)

3.7.1 #2 SINK

a. Connect voltmeter from GND to J5 - 10, observe reading 0 V $\frac{-0\,V}{+.2\,V}$.

b. Jumper J5-2 to GND, observe reading +20 V $\frac{+0\,V}{-.2\,V}$.

c. Remove jumper.

3.7.2 #1 SINK

Push MARKER button.

a. Connect voltmeter from GND to J5 - 11, observe reading 0 V $\frac{-0\,V}{+.2\,V}$.

b. Jumper J5 - 2 to GND, observe reading 20 V $\frac{+0\,V}{-.2\,V}$.

c. Remove jumper.

3.7.3 FRONT PANEL MODE SWITCHES

a. Depress FULL BAND (front panel). Connect SWEEP out to HORIZONTAL input of scope. Center and adjust for full scale sweep.

b. Connect marker out of 6602 to vertical input of scope. Depress RF marker. F_o, M1, M2 markers should appear.

c. Center the F_o marker between M1 and M2 markers. Depress M1, M2 sweep. F_o marker should be expanded and in center of screen.

d. Adjust M1 and M2 dial markers to a position five small divisions on the 6600 dial plate left and right respectively from F_o. Depress ΔF button. Turn ΔF from full CCW to full CW. M1 and M2 markers should appear from left and right respectively and converge to middle of screen.

e. Depress F_o button. Turn F_o pot from 0% to 100%. Observe F_o Marker to move from left to right under control of pot.

f. Depress F_o FINE button. Turn F_o FINE pot from full CCW to full CW. Observe F_o Marker to move from left to right -5 to +5% of scale.

3.7.4 COMPUTER INPUT (For 6600's with Option 5 installed)

a. With an ohmmeter, measure the resistance between J5 - 37 and J5 - 44. The circuit should be open.

b. Connect a jumper between J5 - 2 and GND. J5 - 37 and J5 - 44 should now be a short.

TABLE 4-3. ALIGNMENT PROCEDURE, MODEL 6600 (CONT.)

c. All front panel controls should now be disabled.

d. Connect a jumper between J5 - 3 and GND. J5 - 37 and J5 - 44 should now register as an open.

e. The instrument should now operate in the F_o mode. Connect the sweep output to the horizontal input of the scope. Horizontal position of the spot should be under control of the F_o pot.

f. Remove jumper between J5 - 3 and GND. Connect jumper between J5 - 4 and GND. Instrument should be in F_o FINE mode.

g. Remove jumper between J5 - 4 and GND. Connect jumper between J5 - 5 and GND. Instrument should be in ΔF mode.

h. Remove jumper between J5 - 5 and GND. Connect jumper between J5 - 7 and GND. Instrument should be in M1 → M2 sweep mode.

i. Remove jumper between J5 - 7 and GND. Connect jumper between J5 - 8 and GND. Instrument should be in FULL BAND mode.

j. Remove jumpers. Instrument should now be under control of front panel.

k. Test of computer input is complete.

3.8 MODEL 6600 FUNCTIONAL CHECK

3.8.1 DIAL ACCURACY

NOTE

Unless otherwise specified, all measurements should be made after dial position adjustments are made in the CW direction, i.e., with pointer moving up-scale.

3.8.1.1 CW CALIBRATION

a. Push F_o CW pushbutton and set F_o pointer to 0% dial. Connect test lead of voltmeter and scope lead simultaneously to F1 test point on Model 6602 and observe voltage readings as listed in Table 3.

b. Record maximum P-P ripple and noise.

c. Push F_o pushbutton. Connect test lead of voltmeter and scope lead, simultaneously, to 6600 VPF test point and observe voltage readings as listed in Table 3.

d. Observe maximum P-P ripple and noise. Peak to peak amplitude should not exceed 20 mV.

TABLE 3. VOLTAGE MEASUREMENTS VS. FREQUENCY DIAL READINGS

% of Dial F_o, M1, M2	F1 (±.010V)	VPF (±.050V)
0	0.000	+ 9.600
10	+ 1.000	+ 7.680
20	+ 2.000	+ 5.760
30	+ 3.000	+ 3.840
40	+ 4.000	+ 1.920
50	+ 5.000	0.000
60	+ 6.000	- 1.920
70	+ 7.000	- 3.840
80	+ 8.000	- 5.760
90	+ 9.000	- 7.680
100	+10.000	- 9.600

TABLE 4-3. ALIGNMENT PROCEDURE, MODEL 6600 (CONT.)

3.8.1.2 M1 → M2 SWEEP CALIBRATION

a. Push M1 → M2 pushbuttons. Push .01 SEC sweep and set VARIABLE control to CAL and superimpose the two pointers at the 0.50, and 100% points of dial. The voltage should be as listed in Table 3.

b. DC-couple the scope and note the amplitude of the ramp. It should be less than 20 mV P-P.

3.8.1.3 ΔF SWEEP CALIBRATION

a. Push the CW pushbutton and adjust the F_o control until the voltmeter reads 0.00 V. Set the Δ F pointer and F_o fine pointer to their 0 calibration lines respectively. Push $F_o/\Delta F$ pushbutton. The voltage should not change.

b. Set ΔF to the 25%, 50%, 75% and 100% points on its dial and read sawtooth amplitudes of ±.480 V, ±.960 V, ±1.440 V, and ±1.920 V, ±1%, respectively, centered around 0 volts.

3.8.1.4 CW FINE VERNIER CALIBRATION

a. Push CW FINE pushbutton. The voltmeter should read 0.000 ± 1 mV.

b. Set the F_o FINE pointer to the left and right hand calibration limits. The voltmeter should read ±.960 V ± 10 mV.

SECTION V
PARTS LIST

5-1. INTRODUCTION.

5-2. This parts list section includes all pertinent data necessary to locate, identify, and procure additional parts for the equipment. Parts are listed alphanumerically by reference symbol and include all replaceable electronic items. In some cases, values, ratings and manufacturer sources shown are nominal and variations may be found. Satisfactory replacement may be made with either the listed component or an exact replacement of the part(s) removed from the equipment.

5-3. ORDERING INFORMATION.

5-4. The following instructions will aid in ordering parts from the parts list.

a. Address all inquiries or orders to:

CUSTOMER SERVICE
The Singer Company
3176 Porter Drive
Palo Alto, California 94304

b. Include the following information:

1) Model and Serial Number of instrument.
2) Singer Part Number.
3) Reference Symbol Number.
4) Description (as shown on Parts List).

5-5. HOW TO USE THE PARTS LIST.

5-6. Paragraphs 5-7 through 5-16 describe the use and meaning of the five columns included in the Parts List, Table 5-5. Table 5-1 lists the assemblies covered by the Parts List. Table 5-2 lists the manufacturer's code. Table 5-3 is a list of circuit reference symbols. Table 5-4 is a list of abbreviations used with this Parts List. Table 5-5 is a list of parts used in the Model 6600.

5-7 CIRCUIT REFERENCE.

5-8. The Circuit Reference Column contains an alphanumeric listing of parts as they appear on the equipment chassis, illustration, or schematic. The reference designation identifies the parts as to their component function in the instrument.

5-9 DESCRIPTION COLUMN.

5-10. The Description Column contains the identification of component parts, including all pertinent specifications. When the description column is used for a reference symbol for which no part exists, NOT ASSIGNED is placed in the column. In these instances, columns 3, 4, and 5 are left blank.

5-11 SINGER PART NUMBER COLUMN.

5-12. The Singer Part Number column contains the part number as designated by the Singer Company.

5-13 TRUE FSC NUMBER COLUMN.

5-14. The True FSC Number column references the manufacturer by an assigned code number, as listed in Federal Supply Code Handbook H4-2. For manufacturers not listed in the Handbook, a letter code will be assigned. Table 5-2 includes the manufacturer and his code designation.

5-15 TRUE MANUFACTURER'S PART NUMBER COLUMN.

5-16. The True Manufacturer's Part Number shown contains the part number as designated by the manufacturer of the part.

TABLE 5-5. REPLACEABLE PARTS MODEL 6610ED SERIES (CONTINUED)

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A1	(Cont.)			
	RESISTORS			
R54	22.1 kΩ	59-22.1K	19701	MF5C-D-2212F
R55	10.0 kΩ	59-10.0K	19701	MF5C-D-1002F
R56	Factory Selected			
R57	4.02 kΩ	59-4.02K	19701	MF5C-D-4021F

TABLE 5-1. ASSEMBLIES LISTED IN PARTS LIST

Circuit Reference	Description	Circuit Reference	Description
A1	Power Supply Module	A6	Ramp Generator PC Assembly
A2	Regulator #1 Assembly	A7	Rear Panel Board Assembly
A3	Regulator #2 Board PC Assembly	A8	Computer Interface Board
A4	Modulation PC Assembly	A9	Pot Board Assembly
A5	Control PC Assembly	A9A1	Function Board Assembly

TABLE 5-2. FEDERAL SUPPLY CODE FOR MANUFACTURERS

FSC No.	Name and Address of Vendor
IND-STD	Industry Standard. Order from any manufacturer.
MILPN	Military Part Number
01121	Allen Bradley Co., 136 W. Greenfield Avenue, Milwaukee, Wisconsin
01281	Pacific Semiconductor Co., 10451 W Jefferson Blvd., Culver City, California
01295	Texas Instruments, Inc., 13500 North Central Expressway, Dallas, Texas
02114	Ferroxcube Corp. of America, Mt. Marion Road, Saugerties, New York
03782	Singer Company, Alfred Operation, 3176 Porter Drive, Palo Alto, California
04713	Motorola Semiconductor Products, 5005 E McDonnell Road, Phoenix, Arizona
07263	Fairchild Semiconductor, 545 Whisman Road, Box 880, Mountain View, California
09353	C and K Components, Inc., 103 Morse, Newton, Massachusetts
12697	Clarostat Mfg. Co., Washington Street, Dover, New Hampshire
13919	Burr-Brown Research Corp., P.O. Box 11400, Tucson, Arizona
14099	Semtech Corp., 652 Mitchell Road, Newbury Park, California
14433	ITT Semiconductors, 3301 Electronics Way, West Palm Beach, Florida
14552	Micro Semiconductor Corp., 11250 Playa Court, Culver City, California
14655	Cornell-Dublier Electric, 50 Paris Street, Newark, New Jersey
14752	Electro Cube, Inc., Route US #1 Box 246, Laurel, Maryland
16546	US Capacitor Corp., 8917 Melrose, Los Angeles, California
18324	Signetics Corp., 811 East Argues, Sunnyvale, California
18795	Cycon, Inc., 1080 E. Duane Ave., Sunnyvale, California
19701	Electra Mfg., 800 North 21st, Independence, Kansas
26483	Monsanto Co., Electronics Test and Measurement Dept., 620 Passaic Ave, West Caldwell, New Jersey
31951	Triridge Corp., Route 51, Aliquippa, Pennsylvania
32293	Intersil, Inc., 10900 N. Tantau Avenue, Cupertino, California
37942	Mallory Capacitor Co., 3029 E. Washington Street, Indianapolis, Indiana
56289	Sprague Electric Co., 91 Marshall Street, North Adams, Massachusetts
71590	Centralab, Electronics Div., Globe Union, 034 Keefe Avenue, Miluaukee, Wisconsin
71744	Chicago Miniature Lamp Works, 4433 Ravenswood Avenue, Chicago, Illinois
72982	Erie Technological Products, Inc., 644 W 12th Street, Erie, Pennsylvania
73138	Beckman Instruments, Inc., Helipot Division, 2500 Harbor Blvd., Fullerton, California
75042	IRC, Inc., 401 N. Broad Street, Philedelphia, Pennsylvania
80294	Bourns, Inc., 1200 Columbia Ave., Riverside, California
84048	IRC, Inc, Circuit Instruments Division, 2801 72nd Street, N. St. Petersburg, Indiana
92703	Kemtron Electron Products, Inc., 14 Prince Place, Newberry, Massachusetts
97574	ITT Export Corp., 250 Broadway, New York, New York

TABLE 5-3. REFERENCE SYMBOLS

.AT	Attenuator, Isolator	IS	Optical Isolator
C	Capacitor	P	Plug, Connector
CR	Diode	Q	Transistor
CD	Directional Coupler	R	Resistor
DS	Lamp	S	Switch
IC	Int. Circuit Logic Module	T	Transformer
J	Jack, Connector	U	Integrated Circuit
K	Relay	Z	Miscellaneous Parts: Ferrite Beads (RF Choke)
L	Inductor		

TABLE 5-4. ABBREVIATIONS

AF	Audio Frequency, 30 Hz - 30 kHz	mV	Millivolts
Cer.	Ceramic	mW	Milliwatts
Comp.	Composition	No.	Number
Dep. Car.	Deposited Carbon	NPNT	N Pole N Throw (N=Digit)(S=Single)
DM	Dipped Mica	Oper. Ampl.	Operational Amplifier
Elec.	Electrolytic, Aluminum	P/O	Part of
EHF	Extremely High Frequency, 30 - 300 GHz	Pot.	Potentiometer
F	Frequency	pF	Picofarad
Fact. Sel.	Factory Selected	RF	Radio Frequency
Freq. Mul	Frequency Multiplier	Rect.	Rectifier
GMV	Guaranteed Minimum Value	SAF	Sub Audio Frequency, 0 - 30 Hz
GP	General Purpose	SHF	Super High Frequency, 3.0 - 30 GHz
HC	Hot Carrier (Diode)	Spec.	Special
HF	High Frequency, 3 - 20 MHz	Tant.	Tantalum, Electrolytic
IND-STD	Industry Standard	UHF	Ultra High Frequency, 300 - 3000 MHz (0.3 - 3.0 GHz)
k	Thousand		
LED	Light Emitting Diode	V	Volts
LF	Low Frequency, 30 - 300 kHz	Var.	Variable
m	0.001 (1/1000)	VHF	Very High Frequency, 30 - 300 MHz
M	Million	W	Watts
mA	Milliamperes	WW	Wirewound
MF	Metal Film	0 TC	Zero Temperature Coefficient
Med. Freq.	Medium Frequency, 300 - 3000 kHz	%	± % if sign not shown
Mfr.	Manufacturer	Ω	Ohms
		µF	Microfarads

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A1	POWER SUPPLY MODULE	103-2174-001	03782	103-2174-001
	CAPACITORS			
	NOTE: Unless otherwise specified, all capacitors are fixed electrolytic.			
C1, C2	2300 µF, -10% +100%, 35 V	150-5021-001	14655	FAH-232-35-A1
C3, C4	400 µF, -10% +75%, 100 V	150-5019-001	14655	FAH-401-100-A1
C5, C6	3900 µF, -10% +100%, 20 V	150-5020-001	14655	FAH-392-20-A1
	DIODES			
CR1 thru CR8	3S1-6	81-328	14099	3S1-6
CR9 thru CR16	1N4005	81-20	IND-STD	1N4005
CR17 thru CR24	3S1-6	81-328	14099	3S1-6
CR25, CR26	1N4148	81-260	IND-STD	1N4148
	INDUCTORS			
T1	Transformer	91-222	03782	91-222
	RESISTORS			
	NOTE: Unless otherwise specified, all resistors are fixed 1/4 W, ±1% metal film.			
R1, R2	10 kΩ	59-10.0K	19701	MF5C-D-1002F
R3, R4	47.5 kΩ	59-47.5K	19701	MF5C-D-4752F
R5 thru R7	10 kΩ	59-10.0K	19701	MF5C-D-1002F
R8, R9	1 kΩ	59-1.00K	19701	MF5C-D-1001F
A2	REGULATOR #1 ASSEMBLY	952-347	03782	952-347
	INTEGRATED CIRCUITS			
U1 thru U4	Operational Amplifier	84-1	18324	LM101AT
	CAPACITORS			
	NOTE: Unless otherwise specified, all capacitors are fixed ceramic.			
C1, C2	10 µF, ±20%, 35 V, Elec.	12-100	97574	TAG-10/35-20
C3	500 pF, ±10%, 1 kV	12-26	71590	CRL-DD-501-Z5R
C4	0.47 µF, ±20%, 100 V	12-82	16546	CY30A474M
C5	2 µF, ±2%, 50 V, polycarbonate	14-53	18489	PMT-205H.5A
C6, C7	10 µF, ±20%, 35 V, Elec.	12-100	97574	TAG-10/35-20
C8	500 pF, ±10%, 1 kV	12-26	71590	CRL-DD-501-Z5R
C9, C10	0.47 µF, ±20%, 100 V	12-82	16546	CY30A474M
C11	1 µF, ±20%, 50 V	12-94	72982	8131-M050-651-105M

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A2	(Continued)			
C12	10 µF, ±20%, 35 V, Elec.	12-100	97574	TAG-10/35-20
C13, C14	500 pF, ±10%, 1000 V	12-26	71590	CRL-DD-501-Z5R
C15, C16	27 pF, ±5%, 1000 V, 0 TC	12-21	72982	831-U2M-270K
C17, C18	10 µF, ±20%, 35 V, Elec.	12-100	97574	TAG-10/35-20
	DIODES			
CR1, CR2	1N4005	81-20	IND-STD	1N4005
CR3	1N4148	81-260	IND-STD	1N4148
CR4	Zener, ±5%, 4.7 V, Low noise, 0.6 W	81-281	01281	LVA47A
CR5, CR6	1N4005	81-20	IND-STD	1N4005
CR7 thru CR9	1N4148	81-260	IND-STD	1N4148
CR10	1N4005	81-20	IND-STD	1N4005
CR11, CR12	Zener, ±5%, 15 V, 1 W	81-205	IND-STD	1N4744A
CR13	Zener, ±5%, 6.2 V, 0.4 W	81-75	IND-STD	1N823A
CR14, CR15	Zener, ±5%, 22V, 1 W	81-286	IND-STD	1N4748A
CR16	1N4005	81-20	IND-STD	1N4005
	INDUCTORS			
L1 thru L4	Choke, 7500 Ω/50 MHz, ±20%	156-7005-002	02114	VK200-10/3B
	TRANSISTORS			
Q1	MJE3055	81-270	04713	MJE3055
Q2	2N3904	556-146-989	IND-STD	2N3904
Q3, Q4	2N5089	153-3016-001	IND-STD	2N5089
Q5	IT124	81-302	14433	IT-124
Q6	MJE3055	81-270	04713	MJE3055
Q7	2N3906	556-146-988	IND-STD	2N3906
Q8	MJE2955	81-277	04713	MJE2955
Q9, Q10	2N5089	153-3016-001	IND-STD	2N5089
Q11	IT124	81-302	14433	IT-124
Q12	MJE1092	81-294	04713	MJE1092
Q13	2N3906	556-146-988	IND-STD	2N3906
Q14	2N3904	556-146-989	IND-STD	2N3904
Q15	MJE1102	81-295	04713	MJE1102
Q16	2N5964	153-3033-001	IND-STD	2N5964
Q17	2N4889	153-3023-001	IND-STD	2N4889
	RESISTORS NOTE: Unless otherwise specified, all resistors are fixed, 1/4 W, ±1% metal film.			
R1	3.9 Ω, ±5%, 1/2 W, WW	44-3.9	75042	BWH-3.9 Ω/±5%/1/2 W

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A2	(Continued)			
R2	100 Ω	59-100	19701	MF5C-D-1000F
R3	200 Ω	59-200	19701	MF5C-D-2000F
R4	499 Ω	59-499	19701	MF5C-D-4990F
R5	523 Ω	59-523	19701	MF5C-D-5230F
R6, R7	200 kΩ	59-200K	19701	MF5C-D-2003F
R8	243 kΩ	59-243K	19701	MF5C-D-2433F
R9	1.18 kΩ	59-1.18K	19701	MF5C-D-1181F
R10	Trimpot, 100 Ω, ±10%, 1 W	71-96	73138	79PR100
R11	953 Ω	59-953	19701	MF5C-D-9530F
R12	200 Ω	59-200	19701	MF5C-D-2000F
R13	100 Ω	59-100	19701	MF5C-D-1000F
R14	3.9 Ω, ±5%, 1/2 W, WW	44-3.9	75042	BWH-3.9 Ω/±5%/1/2 W
R15	19.1 kΩ	59-19.1K	19701	MF5C-D-1912F
R16	1.05 kΩ	59-1.05K	19701	MF5C-D-1051F
R17, 18	200 kΩ	59-200K	19701	MF5C-D-2003F
R19	196 kΩ	59-196K	19701	MF5C-D-1963F
R20, R21	1 kΩ	59-1.00K	19701	MF5C-D-1001F
R22	Trimpot, 100 Ω, ±10%, 1 W	71-96	73138	79PR100
R23	2 kΩ	59-2.00K	19701	MF5C-D-2001F
R24	0.27 Ω, ±5%, 1/2 W, WW	44-.27Ω	75042	BWH-0.27Ω/±5%/1/2W
R25	100 Ω	59-100	19701	MF5C-D-1000F
R26	1.21 kΩ	59-1.21K	19701	MF5C-D-1211F
R27	3.24 kΩ	59-3.24K	19701	MF5C-D-3241F
R28	1.21 kΩ	59-1.21K	19701	MF5C-D-1211F
R29	0.27 Ω, ±5%, 1/2 W, WW	44-.27Ω	75042	BWH-0.27Ω/±5%/1/2W
R30	100 Ω	59-100	19701	MF5C-D-1000F
R31	2.94 kΩ	59-2.94K	19701	MF5C-D-2941F
R32	3.83 kΩ	95-3.83K	19701	MF5C-D-3831F
R33	3.24 kΩ	59-3.24K	19701	MF5C-D-3241F
R34	3.83 kΩ	59-3.83K	19701	MF5C-D-3831F
R35	2.67 kΩ	59-2.67K	19701	MF5C-D-2671F
R36, R37	1.21 kΩ	59-1.21K	19701	MF5C-D-1211F
R38	715 Ω	59-715	19701	MF5C-D-7150F
R39	1.74 kΩ	59-1.74K	19701	MF5C-D-1741F
R40	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R41	Trimpot, 200 Ω, ±10%, 1 W	71-90	73138	79PR200
R42	10 kΩ	59-10.0K	19701	MF5C-D-1002F
R43, R44	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A2	(Continued)			
R45	2.1 kΩ	59-2.10K	19701	MF5C-D-2101F
R46	Trimpot, 100 Ω, ±10%, 1 W	71-96	73138	79PR100
R47	953 Ω	59-953	19701	MF5C-D-9530F
R48	Factory Select			
A3	REGULATOR #2 PC BOARD ASSEMBLY	952-348	03782	952-348
	INTEGRATED CIRCUITS			
U1 thru U4	Oper. Ampl.	84-1	18324	LM101AT
	CAPACITORS			
	NOTE: Unless otherwise stated, all capacitors are fixed ceramic.			
C1	500 pF, ±10%, 1 kV	12-26	71590	CRL-DD-501-Z5R
C2	27 pF, 600 V, 0 TC, ±5%	12-21	72982	831-U2M-270K
C3	500 pF, 1 kV ±10%	12-26	71590	CRL-DD-501-Z5R
C4	27 pF, 600 V, 0 TC, ±5%	12-21	72982	831-U2M-270K
C5	0.001 µF, ±2%, 100 V Mica	150-2002-102	14655	CD15FA102G03
C6	360 pF, ±2%, 500 V Mica	150-2002-361FGD	14655	CD15FD361G03
C7	220 µF, 10 V, ±20%, Tant.	13-98	92703	T362D227M010
C8, C9	10 µF, 35 V, ±20%, Elec.	12-100	97547	TAG-10/35-20
C10	0.001 µF ±2%, 500 V, Mica	150-2002-102	14655	CD15FA102G03
C11	360 pF, ±20%, 500 V, Mica	150-2002-361FGD	14655	CD15FD361G03
C12	220 µF, 10 V, ±20%, Tant.	13-98	92703	T362D227M010
C13	500 pF, 1 kV ±10%	12-26	71590	CRL-DD-501-Z5R
C14	27 pF, 600 V, 0 TC, ±5%	12-21	72982	831-U2M-270K
C15	220 µF ±20%, 10 V, Tant.	13-98	92703	T362D227M010
C16	NOT ASSIGNED			
C17	1.0 µF, ±20%, 100 V, Mylar	150-3006-001	14752	210C1B105M
C18	NOT ASSIGNED			
C19	1.0 µF, ±20%, 100 V, Mylar	150-3006-001	14752	210C1B105M
C20, C21	0.1 µF, ±20%, 100 V	12-72	72982	8131-100-651-104M
C22, C23	10 µF, ±20%, 35 V, Elec.	12-100	97574	TAG-10/35-20
	DIODES			
CR1	Zener, 47 V, ±5%, 1 W, 1N4756A	81-125	IND-STD	1N4756A
CR2 thru CR4	1N4005	81-20	IND-STD	1N4005
CR5	Zener, 47 V, ±5%, 1 W	81-125	IND-STD	1N4756A
CR6 thru CR11	1N4005	81-20	IND-STD	1N4005

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A3	(Continued)			
CR12	3S1-6	81-328	14099	3S1-6
CR13, CR14	NOT ASSIGNED			
CR15, CR16	1N4005	81-20	IND-STD	1N4005
CR17	NOT ASSIGNED			
CR18	Zener, 15 V, ±5%, 1 W	81-205	IND-STD	1N4744A
	INDUCTORS			
L1, L2	Choke, 750 Ω/ 50 MHz, ±20 %	156-7005-002	02114	VK-200-10/3B
	TRANSISTORS			
Q1	MJE1092	81-294	04713	MJE1092
Q2	2N3906	556-146-988	IND-STD	2N3906
Q3	2N5964	153-3033-001	IND-STD	2N5964
Q4	2N4889	153-3023-001	IND-STD	2N4889
Q5	2N3904	556-146989	IND-STD	2N3904
Q6	MJE1102	81-295	04713	MJE1102
Q7	MJE1092	81-294	04713	MJE1092
Q8	2N3906	556-146-988	IND-STD	2N3906
Q9	MJE3055	81-270	04713	MJE3055
Q10	2N6178	153-5005-001	IND-STD	2N6178
Q11	2N5964	153-3033-001	IND-STD	2N5964
Q12	2N4889	153-3023-001	IND-STD	2N4889
Q13	2N3904	556-146-989	IND-STD	2N3904
Q14	MJE2955	81-277	04713	MJE2955
Q15	2N6180	153-5006-001	IND-STD	2N6180
Q16	MJE1102	81-295	04713	MJE1102
	RESISTORS			
	NOTE: Unless otherwise specified, all resistors are fixed 1/4 W, ±1% metal film.			
R1	1.5 Ω, 1/2 W, 5%, WW	44-1.5	75042	BWH-1.5Ω/±5%/1/2W
R2	1.21 kΩ	59-1.21K	19701	MF5C-D-1211F
R3	54.9 kΩ	59-54.9K	19701	MF5C-D-5492F
R4	1.78 kΩ	59-1.78K	19701	MF5C-D-1781F
R5	20 kΩ	59-20.0K	19701	MF5C-D-2002F
R6	12.4 kΩ, 1/2 W	56-12.4K	19701	MF6C-D-1242F
R7	2.1 kΩ	59-2.10K	19701	MF5C-D-2101F
R8	1.78 kΩ	59-1.78K	19701	MF5C-D-1781F
R9, R10	1.21 kΩ	59-1.21K	19701	MF5C-D-1211F
R11, R12	1.78 kΩ	59-1.78K	19701	MF5C-D-1781F

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A3	(Continued)			
R13	20 kΩ	59-20.0K	19701	MF5C-D-2002F
R14	12.4 kΩ, 1/2 W	56-12.4K	19701	MF6C-D-1242F
R15	2.1 kΩ	59-2.10K	19701	MF5C-D-2101F
R16	1.5 Ω, 1/2 W, 5%, WW	44-1.5	75042	BWH-1.5Ω/±5%/½W
R17	1.21 kΩ	59-1.21K	19701	MF5C-D-1211F
R18	54.9 kΩ	59-54.9K	19701	MF5C-D-5492F
R19	1.5 Ω, 1/2 W, 5%, WW	44-1.5	75042	BWH-1.5Ω/±5%/½W
R20	169 Ω	59-169	19701	MF5C-D-1690F
R21	1.78 kΩ	59-1.78K	19701	MF5C-D-1781F
R22	10 Ω	59-10.0	19701	MF5C-D-10R0F
R23	169 Ω	59-169	19701	MF5C-D-1690F
R24	0.56Ω, ±5%, ½ W, WW	44-.56	75042	BWH-0.56Ω/±5%/½W
R25	49.9 kΩ	59-49.9K	19701	MF5C-D-4992F
R26	20 kΩ	59-20.0K	19701	MF5C-D-2002F
R27	1.21 kΩ	59-1.21K	19701	MF5C-D-1211F
R28	12.1 kΩ, ±0.1%, 1/2 W	30-1	19701	MF6C-D-1212B
R29, R30	1.05 kΩ, ±0.1%	31-1.05K	19701	MF5C-D-1051B
R31	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R32	1.21 kΩ	59-1.21K	19701	MF5C-D-1211F
R33	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R34, R35	1.05 kΩ, ±0.1%	31-1.05K	19701	MF5C-D-1051B
R36	12.1 kΩ, ±0.1%, 1/2 W	30-1	19701	MF6C-D-1212B
R37	20 kΩ	59-20.0K	19701	MF5C-D-2002F
R38	1.78 kΩ	59-1.78K	19701	MF5C-D-1781F
R39	169 Ω	59-100	19701	MF5C-D-1690F
R40	1.5Ω, ½W, 5%, WW	44-1.5	75042	BWH-1.5Ω/±5%/½W
R41	10 Ω	59-10.0	19701	MF5C-D-10R0F
R42	169 Ω	59-100	19701	MF5C-D-1690F
R43	0.24Ω, ±5%, ½W, WW	44-0.24	75042	BWH-0.24Ω/±5%/½W
R44	49.9 kΩ	59-49.9K	19701	MF5C-D-4992F
R45 thru R46	2.2MΩ, ±5%, 1/4W Comp	151-1002-225	MILPN	RC07GF225J
A4	MODULATION PC ASSEMBLY	952-349	03782	952-349
	INTEGRATED CIRCUITS			
U1 thru U6	Operational Amplifier	84-1	18324	LM101AT

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A4	(Continued)			
	CAPACITORS			
	NOTE: Unless otherwise specified, all capacitors fixed ceramic.			
C1, C2	10μF, ±20%, 35 V, Elec.	12-100	97574	TAG-10/35-20
C3	270 pF, ±10%, 1000V	12-27	71590	CRL-DD-271
C4	27 pF, ±5%, 1000 V, OTC	12-21	72982	831-U2M-270K
C5 thru C7	10 μF, ±20%, 35V Elec.	12-100	97574	TAG-10/35-20
C8 thru C10	NOT ASSIGNED			
C11	10 μF, ±20%, 35 V, Elec.	12-100	97574	TAG-10/35-20
C12	27 pF, ±5%, 1000 V, 0 TC	12-21	72982	831-U2M-270K
C13	0.01 μF, 2%, 200 V, mylar	14-26	18489	VT103H2A
C14, C15	10 μF, ±20%, 35 V, Elec.	12-100	97574	TAG-10/35-20
C16, C17	27 pF, ±5%, 1000V, OTC	12-21	72982	831-U2M-270K
C18 thru C20	10 μF, ±20%, 35V, Elec.	12-100	97574	TAG-10/35-20
C21	500 pF, ±10%, 1000 V	12-26	71590	CRL-DD-501-Z5R
	DIODES			
CR1	1N4148	81-260	IND-STD	1N4148
CR2	Zener, 4.7 V, ±5%, 1 W	81-311	IND-STD	1N4732A
CR3 thru CR5	1N4148	81-260	IND-STD	1N4148
CR6	NOT ASSIGNED			
CR7 thru CR9	1N4148	81-260	IND-STD	1N4148
CR10	NOT ASSIGNED			
CR11 thru CR14	1N4148	81-260	IND-STD	1N4148
CR15	NOT ASSIGNED			
CR16 thru CR24	1N4148	81-260	IND-STD	1N4148
	RELAY			
K1	Reed, SPDT 24 V	106-61	31951	220-001-24
	INDUCTORS			
L1 thru L10	Choke, 750Ω/50 MHz, ±20%	156-7005-002	02114	VK200 -10/3B
	TRANSISTORS			
Q1, Q2	MPS A66	81-292	04713	MPS A66
Q3	IT 122E	81-268	32293	IT122E
Q4	2N5089	153-3016-001	IND-STD	2N5089

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A4	(Continued)			
Q5, Q6	MPS A66	81-292	04713	MPS A66
Q7	IT 122E	81-268	32293	IT122E
Q8	2N5089	153-3016-001	IND-STD	2N5089
Q9, Q10	MPS A66	81-292	04713	MPS A66
Q11	IT 122E	810268	32293	IT122E
Q12	2N5089	153-3016-001	IND-STD	2N5089
Q13 thru Q16	2N3906	556-146-988	IND-STD	2N3906
Q17	2N5964	153-3033-001	IND-STD	2N5964
Q18	2N4889	153-3023-001	IND-STD	2N4889
Q19	2N5964	153-3033-001	IND-STD	2N5964
Q20	NOT ASSIGNED			
Q21	2N3904	556-146-989	IND-STD	2N3904
Q22	2N6178	153-5005-001	IND-STD	2N6178
Q23	2N6180	153-5006-001	IND-STD	2N6180
Q24	2N5964	153-3033-001	IND-STD	2N5964
	RESISTORS NOTE: Unless otherwise specified all resistors are fixed 1/4 W, ±1% metal film.			
R1	10.5 kΩ	59-10.5K	19701	MF5C-D-1052F
R2	21.5 kΩ	59-21.5K	19701	MF5C-D-2152F
R3	10 kΩ, ±0.1% @ 70°	31-10.0K	19701	MF5C-D-1002B
R4	1 kΩ	59-1.00K	19701	MF5C-D-1001F
R5	100 kΩ	59-100K	19701	MF5C-D-1003F
R6	178 Ω	59-178	19701	MF5C-D-1780F
R7	21.5 kΩ	59-21.5K	19701	MF5C-D-2152F
R8	10 kΩ, ±0.1% @ 70°	31-10.0K	19701	MF5C-D-1002B
R9	21 kΩ, ±0.1% @ 70°	31-21.0K	19701	MF5C-D-2102B
R10	4.64 kΩ	59-4.64K	19701	MF5C-D-4641F
R11	19.6 kΩ	59-19.6K	19701	MF5C-D-1962F
R12	3.83 kΩ	59-3.83K	19701	MF5C-D-3831F
R13	19.2 kΩ, ±0.1% @ 70°	31-19.2K	19701	MF5C-D-1922B
R14	9.53 kΩ	59-953K	19701	MF5C-D-9531F
R15	2.87 kΩ	59-2.87K	19701	MF5C-D-2871F
R16	5.23 kΩ	59-5.23K	19701	MF5C-D-5231F
R17	1 kΩ	59-1.00K	19701	MF5C-D-1001F
R18	75 kΩ, ±0.1% @ 70°	31-75.0K	19701	MF5C-D-7502B
R19	10 kΩ, ±0.1% @ 70°	31-10.0K	19701	MF5C-D-1002B

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A4	(Continued)			
R20	19.2 kΩ, ±0.1% @ 70°	31-19.2K	19701	MF5C-D-1922B
R21	75 kΩ, ±0.1% @ 70°	31-75.0K	19701	MF5C-D-7502B
R22	442 Ω	59-442	19701	MF5C-D-4420F
R23	4.02 kΩ@ 70°	59-4.02K	19701	MF5C-D-4021F
R24	48.7 kΩ, ±0.1% @ 70°	31-48.7K	19701	MF5C-D-4872B
R25	3.48 kΩ	59-3.48K	19701	MF5C-D-3481F
R26	22.1 kΩ	59-22.1K	19701	MF5C-D-2212F
R27	21 kΩ, ±0.1% @ 70°	31-21.0K	19701	MF5C-D-2102B
R28	2 kΩ, 1/2 W	56-2.00K	19701	MF5C-D-2001B
R29	NOT ASSIGNED			
R30	432 Ω	59-432	19701	MF5C-D-4320F
R31	75 kΩ, ±0.1% @ 70°	31-75.0K	19701	MF5C-D-7502B
R32	1 kΩ	59-1.00K	19701	MF5C-D-1001F
R33	19.2 kΩ, ±0.1% @ 70°	31-19.2K	19701	MF5C-D-1922B
R34	10 kΩ, ±0.1% @ 70°	31-10.0K	19701	MF5C-D-1002B
R35	75 kΩ, ±0.1% @ 70°	31-75.0K	19701	MF5C-D-7502B
R36	442 Ω	59-442	19701	MF5C-D-4420F
R37	4.02 kΩ	59-4.02K	19701	MF5C-D-4021F
R38	NOT ASSIGNED			
R39	4.64 kΩ	59-4.64K	19701	MF5C-D-4641F
R40	3.01 kΩ	59-3.01K	19701	MF5C-D-3011F
R41	21 kΩ, ±0.1% @ 70°	31-21.0K	19701	MF5C-D-2102B
R42	2 kΩ, 1/2 W	56-2.00K	19701	MF6C-D-2001F
R43	NOT ASSIGNED			
R44	432 Ω	59-432	19701	MF5C-D-4320F
R45, R46	75 kΩ, ±0.1% @ 70°	31-75.0K	19701	MF5C-D-7502B
R47	1 kΩ	59-1.00K	19701	MF5C -D-1001F
R48	442 Ω	59-442	19701	MF5C-D-4420F
R49	19.2 kΩ, ±0.1% @ 70°	31-19.2K	19701	MF5C-D-1922B
R50	10 kΩ, ±0.1% @ 70°	31-10.0K	19701	MF5C-D-1002B
R51	4.02 kΩ	59-4.02K	19701	MF5C-D-4021F
R52	NOT ASSIGNED			
R53	21.5 kΩ	59-21.5K	19701	MF5C-D-2152F
R54	15 kΩ	59-15.0K	19701	MF5C-D-1502F
R55	21 kΩ, ±0.1% @ 70°	31-21.0K	19701	MF5C-D-2102B
R56	2 kΩ, 1/2 W	56-2.00K	19701	MF6C-D-2001F
R57	432 Ω	59-432	19701	MF5C-D-4320F
R58	1 kΩ	59-1.00K	19701	MF5C-D-1001F

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A4	(Continued)			
R59	4.64 kΩ	59-4.64K	19701	MF5C-D-4641F
R60	21.5 kΩ	59-21.5K	19701	MF5C-D-2152F
R61	10 kΩ	59-10.0K	19701	MF5C-D-1002F
R62	499 Ω	59-499	19701	MF5C-D-4990F
R63	10 kΩ	59-10.0K	19701	MF5C-D-1002F
R64	178 Ω	59-178	19701	MF5C-D-1780F
R65	19.6 kΩ	59-19.6K	19701	MF5C-D-1962F
R66 thru R75	NOT ASSIGNED			
R76	Pot. Trim., 500 kΩ, ±10%, 0.75 W	71-147	75042	960-290-500K
R77	174 kΩ	59-174K	19701	MF5C-D-1743F
R78	10.5 kΩ	59-10.5K	19701	MF5C-D-1052F
R79	10 kΩ	59-10.0K	19701	MF5C-D-1002F
R80	3.32 kΩ	59-3.32K	19701	MF5C-D-3321F
R81	10.5 kΩ	59-10.5K	19701	MF5C-D-1052F
R82	174 kΩ	59-174	19701	MF5C-D-1743F
R83	Pot. Trim., 500 kΩ, ±10%, 0.75 W	71-147	75042	960-290-500K
R84	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R85	20 Ω	59-20.0	19701	MF5C-D-20R0F
R86	10 kΩ	59-10.0K	19701	MF5C-D-1002F
R87	20 Ω	59-20.0	19701	MF5C-D -20R0F
R88	NOT ASSIGNED			
R89	20 kΩ	59-20.0K	19701	MF5C-D-2002F
R90	7.5 kΩ	59-7.50K	19701	MF5C-D-7502F
R91	21 kΩ	59-21.0K	19701	MF5C-D-2102F
R92	348 kΩ	59-348K	19701	MF5C-D-3483F
R93	Pot. Trim., 1 MΩ, ±10%, 0.75 W	71-140	75042	960-290-1M
R94 thru R96	NOT ASSIGNED			
R97, R98	48.7 kΩ, ±0.1% @ 70°	31-48.7K	19701	MF5C-D-4872B
A5	CONTROL P.C. ASSEMBLY	952-350	03782	952-350
	CAPACITORS			
	NOTE: Unless otherwise specified, all capacitors are fixed ceramic.			
C1 thru C3	10 µF, ±20%, 35V, Elec.	12-100	97574	TAG-10/35-20
C4	27 pF, ±5%, 1000 V, 0 TC	12-21	72982	831-U2M-270K

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A5	(Continued)			
	INTEGRATED CIRCUIT			
U1	Operational Amplifier	84-1	07263	LM101A
	DIODES			
CR1 thru CR93	1N4148	81-260	IND-STD	1N4148
	RELAYS			
K1 thru K3	SPST, 24 V	106-53	31951	220-100-24
K4	SPDT, 24 V	106-61	31951	220-001-24
K5	SPST, 24 V	106-53	31951	220-100-24
K6 thru K10	SPDT, 24 V	106-61	31951	220-001-24
K11	SPST, 24 V	106-53	31951	220-100-24
	INDUCTORS			
L1 thru L5	Choke, 750 Ω/50 MHz, ±20%	156-7005-002	02114	VD200, -10/3B
	TRANSISTORS			
Q1 thru Q3	2N3904	556-146-989	IND-STD	2N3904
	RESISTORS			
	NOTE: Unless otherwise specified, all resistors are fixed 1/4 W, ±1% metal film.			
R1	499 Ω	59-499	19701	MF5C-D-4990F
R2	10.0 kΩ	59-10.0K	19701	MF5C-D-1002F
R3	22.1 kΩ	59-22.1K	19701	MF5C-D-2212F
R4 thru R7	4.75 kΩ	59-4.75K	19701	MF5C-D-4751F
R8	10 kΩ	59-10.0K	19701	MF5C-D-1002F
A6	RAMP GENERATOR P.C. ASSEMBLY	952-351	03782	952-351
	INTEGRATED CIRCUITS			
U1 thru U4	LM101A	84-1	18324	LM101AT
IC1	Triple 3 Input NOR Gate	84-23	01295	SN5427
IC2	One Shot Multivibrator	153-7044-001	01295	SN54121N
IC3	Dual Flip-flop	84-22	01295	SN5474
IC4	Quad 2 Input NAND Gate	153-7031-001	01295	SN5400N
IC5	Operational Amplifier	84-21	07263	UGH7805393

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A6	(Continued)			
	CAPACITORS			
	NOTE: Unless otherwise specified, all capacitors are fixed ceramic.			
C1	.01 µF, GMV, 25 V	12-56	56289	HYS 20
C2	33 µF, ±20%, 25 V, Elec.	13-91	92703	T362C336M025AS
C3	.01 µF, GMV, 25 V	12-56	56289	HYS 20
C4	.22 µF, ±20%, 50 V	12-95	14655	NLW-200-25
C5 thru C7	10 µF, ±20%, 35 V, Elec.	12-100	97574	TAG-10/35-20
C8	NOT ASSIGNED			
C9	27 pF, ±5%, 1000 V	12-21	72982	831-U2M-270K
C10, C11	NOT ASSIGNED			
C12	2 µF, ±2%, 50 V, metallized polycarbonate	14-53	18489	PMT205H.5A
C13 thru C18	10 µF, ±20%, 35 V, Elec.	12-100	97574	TAG-10/35-20
C19	0.047 µF, ±20%, 100 V	12-73	72982	8121-651-473M
C20	27 pF, ±5%, 1000 V	12-21	72982	831-U2M-270K
	DIODES			
CR1 thru CR9	1N4148	81-260	IND-STD	1N4148
CR10	LED	81-276	26483	MV10B
CR11	1N270	81-190	IND-STD	1N270
CR12, CR13	1N4148	81-260	IND-STD	1N4148
CR14, CR15	Zener, 4.7 V, ±5%	81-311	IND-STD	1N4732A
CR16 thru CR24	1N4148	81-260	IND-STD	1N4148
CR25	Zener, 10 V, ±5%	81-204	IND-STD	1N4740A
CR26	1N4148	81-260	IND-STD	1N4148
	LAMPS			
DS1 thru DS4	Miniature #388	126-26	71744	388
	RELAYS			
K1	SPDT, 24 V	106-61	31951	220-001-24
	TRANSISTORS			
Q1	MPS A14	81-293	04713	MPS A14
Q2	2N3904	556-146-989	IND-STD	2N3904
Q3	2N6180	153-5006-001	IND-STD	2N6180

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A6	(Continued)			
Q4, Q5	2N3904	556-146-989	IND-STD	2N3904
Q6	2N3906	556-146-988	IND-STD	2N3906
Q7	2N6178	153-5005-001	IND-STD	2N6178
Q8	2N5694	153-3033-001	IND-STD	2N5694
Q9	2N3904	556-146-989	IND-STD	2N3904
Q10	2N3906	556-146-988	IND-STD	2N3906
Q11	2N6180	153-5006-001	IND-STD	2N6180
Q12	2N6178	153-5005-001	IND-STD	2N6178
Q13	2N3904	556-146-989	IND-STD	2N3904
Q14 thru Q16	2N3906	556-146-988	IND-STD	2N3906
	RESISTORS NOTE: Unless otherwise specified, all resistors are fixed 1/4 W, ±1% metal film			
R1	82.5 Ω	59-82.5	19701	MF5C-D-82R5F
R2	Pot., 1 kΩ, ±10%, 5/8" dia., 1/2	151-0001-051	01121	GA2N048P102MA
R3	9.53 kΩ	59-9.53K	19701	MF5C-D-9531F
R4	2 kΩ	59-2.00K	19701	MF5C-D-2001F
R5	95.3 kΩ	59-95.3K	19701	MF5C-D-9532F
R6	9.53 kΩ	59-9.53K	19701	MF5C-D-9531F
R7	953 kΩ	59-953K	19701	MF5C-D-9533F
R8	95.3 kΩ	59-95.3K	19701	MF5C-D-9532F
R9	953 kΩ	95-953K	19701	MF5C-D-9533F
R10	9.53 MΩ, ±1%, 1/8 W	60-9.53M	19701	MF4C-D-9534F
R11	NOT ASSIGNED			
R12	49.9 kΩ	59-33.2K	19701	MF5C-D-3322F
R13	3.95 MΩ, ±5%, 1/4 W, Comp.	151-1002-395J	MILPN	RC07GF3954J
R14	1 kΩ	59-1.00K	19701	MF5C-D-1001F
R15	19.1 kΩ	59-19.1K	19701	MF5C-D-1912F
R16	1 kΩ	59-1.00K	19701	MF5C-D-1001F2F
R17	4.02 kΩ	59-4.02K	19701	MF5C-D-4021F
R18	10 kΩ	59-10.0K	19701	MF5C-D-1002F
R19	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R20	1 kΩ	59-1.00K	19701	MF5C-D-1001F
R21	2 kΩ	59-2.00K	19701	MF5C-D-2001F
R22	10 kΩ	59-10K	19701	MF5C-D-1002F
R23	27.4 kΩ	59-27.4K	19701	MF5C-D-2742F
R24, R25	10 kΩ	59-10.0K	19701	MF5C-D-1002F

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A6	(Continued)			
R26	1 kΩ, ±10%, 1/2 W, carbon	151-1003-102J	MILPN	RC20GF102J
R27	10 kΩ	59-10.0K	19701	MF5C-D-1002F
R28	20 kΩ	59-20.0K	19701	MF5C-D-2002F
R29	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R30	Pot., 1 kΩ, ±10%, 5/8" dia., ½W	151-0001-051	01121	GA2N048P102MA
R31	665 Ω	59-665	19701	MF5C-D-6650F
R32, R33	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R34	10 MΩ, ±10%, 1/2 W, carbon	151-1003-106J	MILPN	RC20GF106J
R35	Pot. Trim, 50 kΩ, ±10%, ½W	556-146-514	73138	62PR50K
R36	5.6 MΩ, ±10%, 1/2 W, carbon	151-1003-565J	MILPN	RC20GF565J
R37	249 Ω	59-249	19701	MF5C-D-2490F
R38	150 Ω	59-150	19701	MF5C-D-1500F
R39	10 Ω	59-10	19701	MF5C-D-10R0F
R40	19.1 kΩ	59-19.1K	19701	MF5C-D-1912F
R41	2.15 MΩ, ±1%, 1/2 W	56-2.15M	19701	MF6C-D-2154F
R42	Pot. Trim., 50 kΩ, ±10%, ½W	556-146-051	73138	62PR50K
R43	150 Ω	59-150	19701	MF5C-D-1500F
R44	10 Ω	59-10	19701	MF5C-D-10R0F
R45	Pot., 1 kΩ, ±10%, 5/8" dia., ½W, w/DPDT switch	71-168	01121	70L1G040R102X
R46	20 kΩ	59-20.0K	19701	MF5C-D-2002F
R47	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R48	2 kΩ	59-2.00K	19701	MF5C-D-2001F
R49	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R50	20 kΩ	59-20.0K	19701	MF5C-D-2002F
R51	1 kΩ	59-1.00K	19701	MF5C-D-1001F
R52	20 kΩ	59-20.0K	19701	MF5C-D-2002F
	SWITCH ASSEMBLY			
S1 thru S11	11XF125	101-37	03782	101-37
S12	Pot., 1 kΩ, ±10%, 5/8" dia., ½W, w/DPDT switch	71-168	01121	70L1G040R102X
A7	REAR PANEL BOARD ASSEMBLY	952-359	03782	952-359
	DIODES			
CR1 thru CR3	1N4148	81-260	IND-STD	IN4148
	TRANSISTORS			
Q1, Q2	2N3906	556-146-988	IND-STD	2N3906

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A7	(Continued)			
	RESISTORS			
	NOTE: Unless otherwise specified, all resistors are fixed 1/4W, 1% metal film.			
R1, R2	NOT ASSIGNED			
R3	Pot., 1 kΩ, ±10%, 2W	151-0059-001	80294	3862C-201-102A
R4	10 kΩ	59-10.0K	19701	MF5C-D-1002F
R5	249 Ω	59-249	19701	MF5C-D-2490F
R6	10 kΩ	59-10.0K	19701	MF5C-D-1002F
R7	24.9 kΩ	59-24.9K	19701	MF5C-D-2492F
R8	9.31 kΩ	59-9.31K	19701	MF5C-D-9311F
	SWITCHES			
S1	Switch, miniature toggle SPST	101-30	09353	7201
A8	COMPUTER INTERFACE BOARD	952-810	03782	952-810
	INTEGRATED CIRCUITS			
U1, U2	IC Regulator, 5 V	84-21	07263	UGH705393
	CAPACITORS			
	NOTE: Unless otherwise specified, all capacitors fixed ceramic.			
C1 thru C3	10μF, ±20%, 35 V, Elec.	12-100	97574	TAG-10/35-20
	DIODES			
CR1, CR2	Zener, 15 V, ±5%, 1W	81-205	IND-STD	1N4744A
CR3 thru CR5	1N4148	IND-STD	14552	1N4148
	TRANSISTORS			
Q1 thru Q31	2N3904	556-146-989	IND-STD	2N3904
	RESISTORS			
	NOTE: Unless otherwise specified, all resistors are fixed 1/4W, 1% metal film.			
R1 thru R62	2 kΩ	59-2.00K	19701	MF5C-D-2001F
R63	20 kΩ	59-20.0K	19701	MF5C-D-2002F
R64	2 kΩ	59-2.00K	19701	MF5C-D-2001F
R65 thru R68	20 kΩ	59-20.0K	19701	MF5C-D-2002F
R69 thru R75	2 kΩ	59-2.00K	19701	MF5C-D-2001F

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A8	(Continued)			
R76, R77	20 kΩ	59-20.0K	19701	MF5C-D-2002F
R78	2 kΩ	59-2.00K	19701	MF5C-D-2001F
R79 thru R93	20 kΩ	59-20.0K	19701	MF5C-D-2002F
R94	NOT ASSIGNED			
R95	20 kΩ	59-20.0K	19701	MF5C-D-2002F
R96 thru R99	NOT ASSIGNED			
R100 thru R107	20 kΩ	59-20.0K	19701	MF5C-D-2002F
R108	NOT ASSIGNED			
R109	20 kΩ	59-20.0K	19701	MF5C-D-2002F
R110, R111	NOT ASSIGNED			
R112 thru R123	10 kΩ	59-10.0K	19701	MF5C-D-1002F
R124	249 Ω	59-249	19701	MF5C-D-2490F
R125	20 kΩ	59-20.0K	19701	MF5C-D-2002F
	OPTICAL ISOLATORS			
IS1, IS2	MCT-2 or TIL-112	158-5001-001	26483	MCT-2
IS3	MCA2-30	158-5002-001	26483	MCA2-30
IS4 thru IS7	MCT-2 or TIL-112	158-5001-001	26483	MCT-2
IS8 thru IS14	MCA2-30	158-5002-001	26483	MCA2-30
IS15, IS16	MCT-2 or TIL-112	158-5001-001	26483	MCT-2
IS17	MCA2-30	158-5002-001	26483	MCA2-30
IS18 thru IS31	MCT-2 or TIL-112	158-5001-001	26483	MCT-2
DAC-1	Converter, digital to analog	84-20	18795	CY2635
A9	POT BOARD ASSEMBLY	952-358	03782	952-358
	INTEGRATED CIRCUITS			
U1, U2	Operational Amplifier	84-1	18324	LM101AT
U3	Low Noise Op. Amp.	153-7056-001	13919	BB35005
U4, U5	Operational Amplifier	84-1	18324	LM101AT

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A9	(Continued)			
	CAPACITORS			
	NOTE: Unless otherwise specified, all capacitors are fixed ceramic.			
C1, C2	27 pF, 1000 V, ±5% OTC	12-21	72982	831-U2M-270K
C3 thru C5	10 µF, ±20%, 35V, Elec.	12-100	97574	TAG-10/35-20
C6	NOT ASSIGNED			
C7	10 µF, ±20%, 35V, Elec.	12-100	97574	TAG-10/35-20
C8, C9	27 pF, 1000 V, ±5% OTC	12-21	72982	831-U2M-270K
C10-C11	10 µF, ±20%, 35V, Elec.	12-100	97574	TAG-10/35-20
C12	NOT ASSIGNED			
C13	100 pF, ±20%, 1000V	12-22	72982	831-000-X5F0-101K
	INDUCTORS			
L1	Choke 750Ω/50MHz±20%	156-7005-002	02114	VK200-10/3B
	TRANSISTORS			
Q1, Q2	2N3906	556-146-988	IND-STD	2N3906
	RESISTORS			
	NOTE: Unless otherwise specified, all resistors are fixed 1/4 W, ±metal film.			
R1	28 Ω	59-28.0	19701	MF5C-D-28R0F
R2 thru R4	10 kΩ	59-10.0K	19701	MF5C-D-1002F
R5	Pot. Trim, 50 kΩ, ±10%, 0.75W	71-153	84048	960-290-50K
R6	NOT ASSIGNED			
R7	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R8	768 Ω	59-768	19701	MF5C-D-7680F
R9	40.2 Ω	59-40.2	19701	MF5C-D-40R2F
R10	Pot., 1000Ω, ±3%, 0.75 W	74-15	12697	73JA-1K±3%
R11	24.9 kΩ	59-24.9K	19701	MF5C-D-2492F
R12	Pot. Trim, 50 kΩ, ±10%, 0.75W	71-153	84048	960-290-50K
R13	Pot., 1000Ω, ±3%, 0.75W	74-15	12697	73JA-1K±3%
R14, R15	499 Ω	59-499	19701	MFC-D-4990F
R16	NOT ASSIGNED			
R17	Pot. Trim, 50 kΩ, ±10%, 0.75W	71-153	84048	960-290-50K
R18	768 Ω	59-768	19701	MF5C-D-7680F
R19	28 Ω	59-28.0	19701	MF5C-D-28R0F
R20	24.9 kΩ	59-24.9K	19701	MF5C-D-2492F
R21	Pot. Trim, 50 kΩ, ±10%, 0.75W	71-153	84048	960-290-50K

CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
A9	(Continued)			
R22	Pot., 1000 Ω, ±3%, 0.75W	74-15	12697	73JA-1K±3%
R23	40.2 Ω	59-40.2	19701	MF5C-D-40R2F
R24	28 Ω	59-28.0	19701	MF5C-D-28R0F
R25, R26	10 kΩ	59-10.0K	19701	MF5C-D-1002F
R27	4.99 kΩ	59-4.99K	19701	MF5C-D-4991F
R28	10 kΩ	59-10.0K	19701	MF5C-D-1002F
R29	Pot. Trim, 50 kΩ, ±10%, 0.75W	71-153	84048	960-290-500K
R30	NOT ASSIGNED			
R31	768 Ω	59-768	19701	MF5C-D-7680F
R32	Pot., 1000Ω, ±3%, 0.75W	74-15	12697	73JA-1K±3%
R33	40.2 Ω	59-40.2	19701	MF5C-D-40R2F
R34	24.9 kΩ	59-24.9K	19701	MF5C-D-2492F
R35	Pot. Trim, 50 kΩ, ±10%, 0.75W	71-153	84048	960-290-500K
R36	NOT ASSIGNED			
R37	Pot., 1000Ω, ±3%, 0.75W	74-15	12697	73JA-1K±3%
A9A1	FUNCTION BOARD ASSEMBLY	952-364	03782	952-364
	Switch Assembly	906-833	03782	906-833
	MOTHER BOARD ASSEMBLY	952-356	03782	952-356
	CAPACITORS			
C1, C2	250 µF, -10+100%, 25 V, fixed Elec.	13-93	37942	MTV250DN25
C3, C4	100 µF, ±20%, 20 V, fixed Tant.	13-89	56289	196D107X0020GB
C5	NOT ASSIGNED			
C6 thru C9	70 µF, -10+100%, 75V, fixed Elec.	13-92	37942	MTV70DN75
	RESISTORS			
R1	499 Ω, 1/4 W, 1%, Fixed MF	59-499	19701	MF5C-D-4990F
R2	10 Ω, 2 W, 10%, Fixed Comp	151-1005-100J	MILPN	RC42GF100J

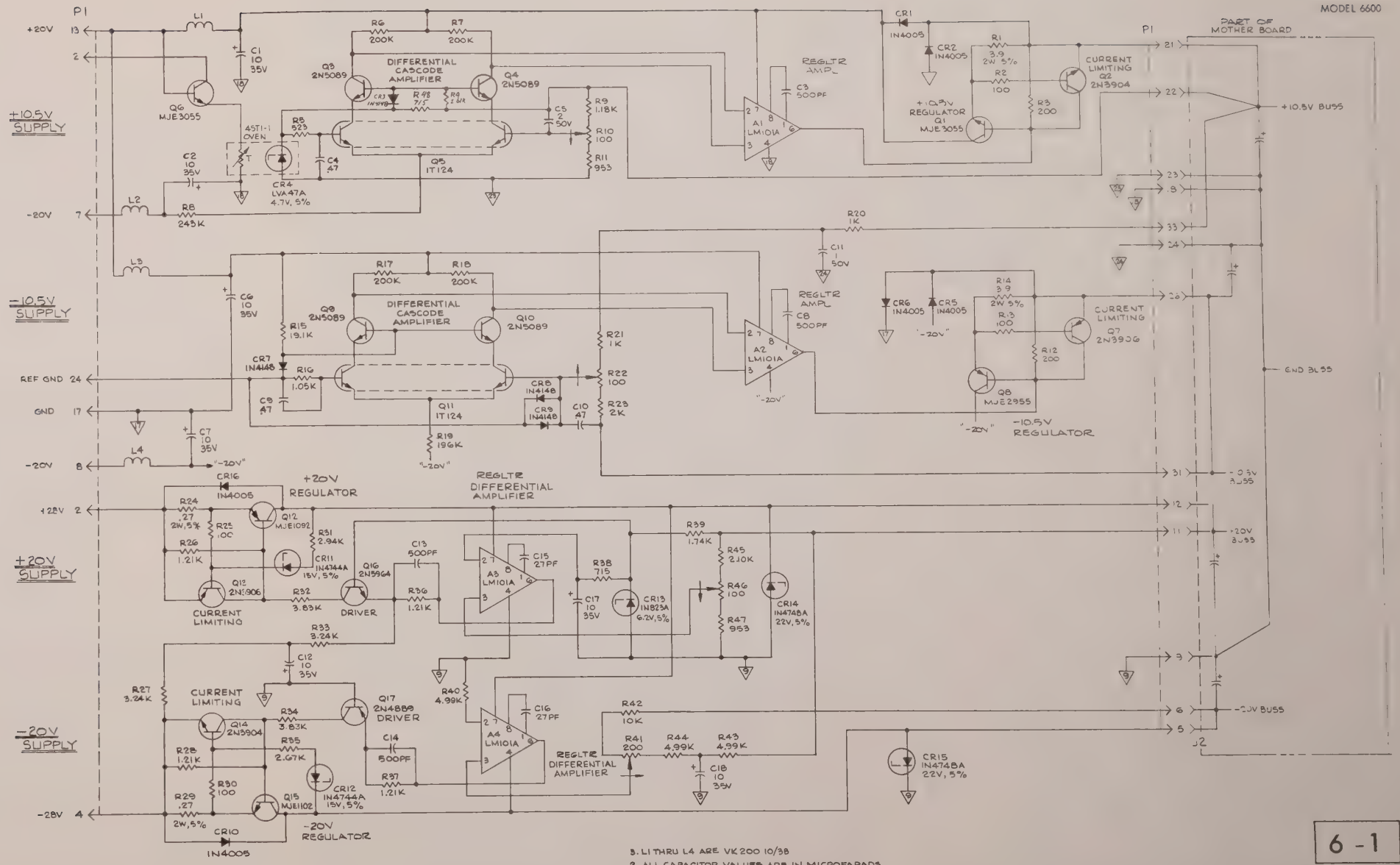
CIRCUIT REFERENCE	DESCRIPTION	SINGER PART NO.	TRUE MFG. FSC NO.	TRUE MFG. PART NO.
	6600 ACCESSORIES LIST			
	CONNECTORS			
	10 Pin Dual-In-Line PC Board Socket	133-137	05574	2VH10/1AV5
	14 Pin Female Flat Cable, Chassis	133-131	02660	57-40140
	14 Pin Male Flat Cable, Cable End	168-2003-003	02660	57-30140
	14 Pin Dual-In-Line PC Board Socket	168-8047-001	91886	122-0162-019
	16 Pin Male Flat Cable, Cable End	133-129	91506	2P16-1
	16 Pin Dual-In-Line PC Board Socket	133-128	91506	516-AG1D
	28 Pin Dual-In-Line PC Board Socket	168-3018-001	89110	2-583660-7
	36 Pin Right Angle Dual-In-Line PC Board Socket	168-3014-001	05574	2VH18/1AKC15
	36 Pin Receptacle Dual-In-Line PC Board Socket	133-130	02660	57-40360
	36 Pin Dual-In-Line PC Board Socket	168-3017-001	89110	583660-1
	44 Contacts Dual-In-Line PC Board Socket	133-132	05574	2VH22/1AV5
	BNC Female, Chassis	131-33	91737	UG-1094A/U
	KNOBS			
	Knob Round Indicator	170-5011-0512	21604	RSS-50L-(L)1/2SCR
	Knob, Round Plain	170-5012-0725	21604	RSSN-70-2
	Knob, Modified	906-548	03782	906-548
	POWER INPUT			
	Module, Power Input	142-7	28480	5060-1188
	Power Cord	142-8	28480	5060-1188
	SWITCH BUTTONS			
	Push Rod Power Switch	116-0981-001	03782	116-0981-001
	Pushbutton Power Switch	121-1012-001	03782	121-1012-001
	Push Rod Assembly for Pushbutton Switches M1→M2, CW, ΔF, CW Fine, Full Band	913-784	03782	913-784
	Pushbutton for RF, Trigger, Sweep Switches	952-274-01	03782	952-274-01
	Pushbutton for M1→M2, CW, ΔF, CW Fine, Full Band	913-897	03782	913-897

SECTION VI

SUPPLEMENTARY SCHEMATIC DIAGRAMS

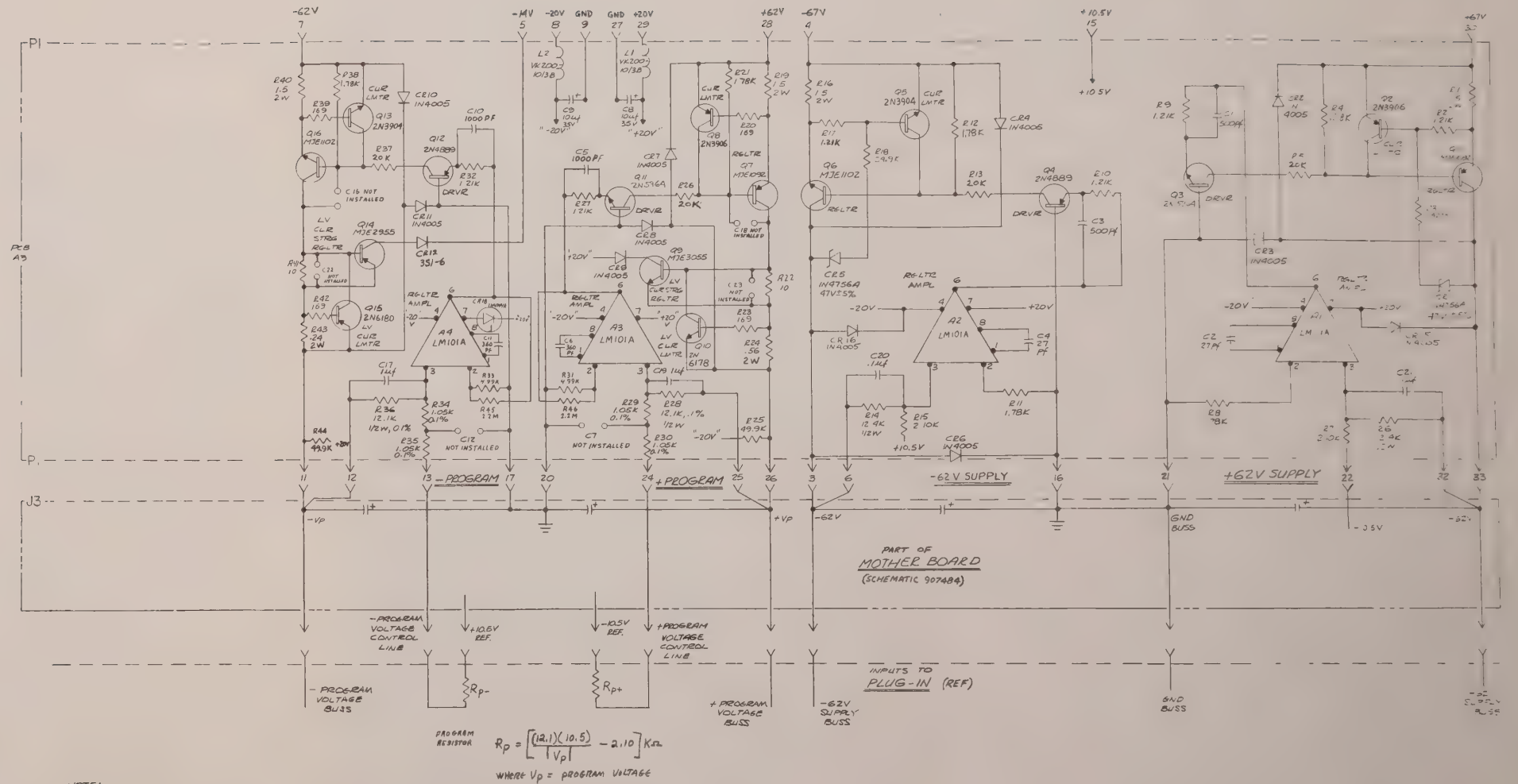
6-1. SUPPLEMENTARY SCHEMATICS BY MODULE RATHER THAN BY FUNCTION.

6-2. These schematics are included to help signal tracing, where signals may flow through several boards between two functional schematics. The paths are indicated, point by point, at entrance and exit terminals of the Functional Schematics in Section IV.



NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 1%.
2. ALL CAPACITOR VALUES ARE IN MICROFARADS.
3. L1 THRU L4 ARE VK200 10/38

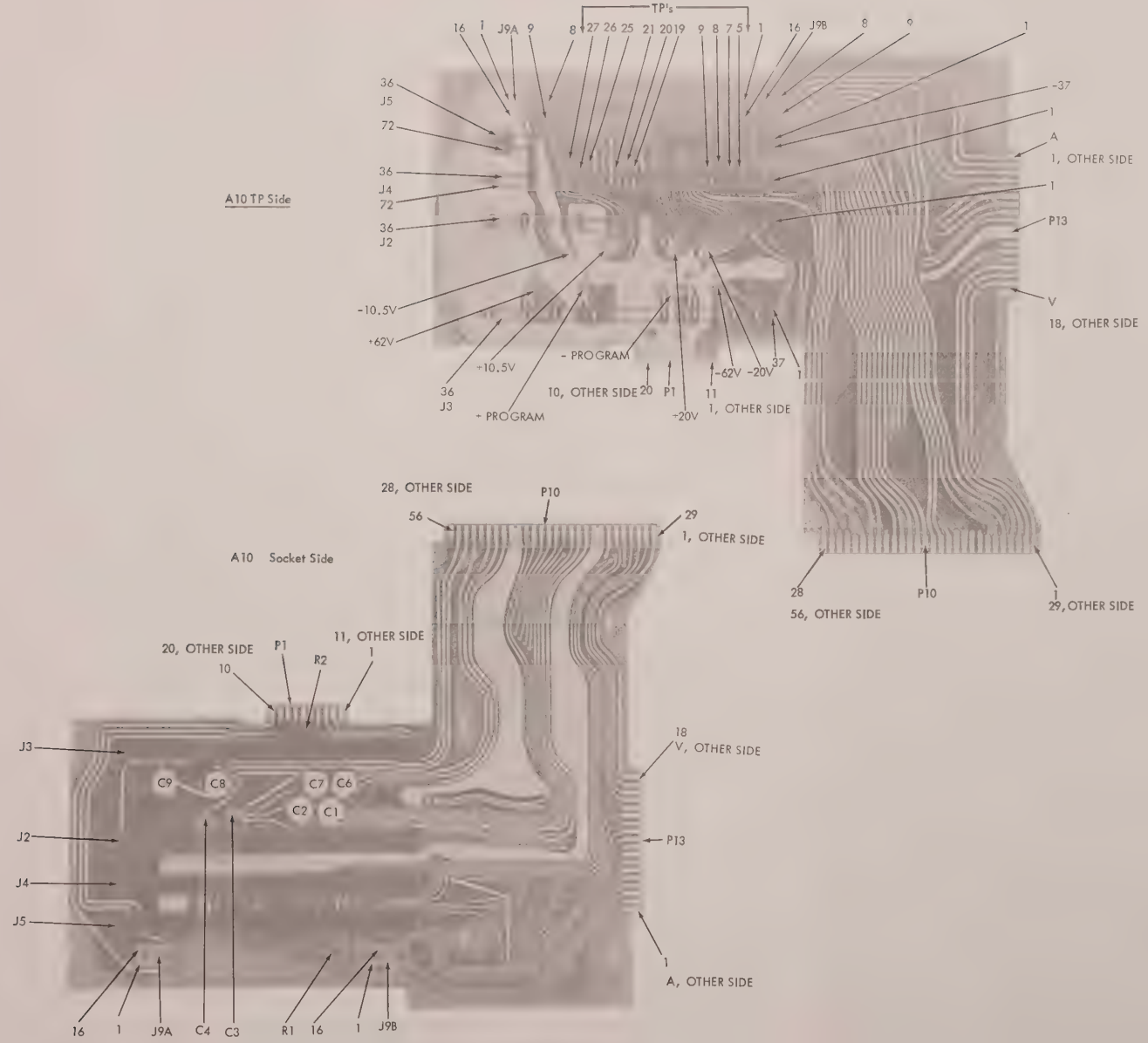
Figure 6-1. Regulator Board, A2



NOTE:
1. UNLESS SPECIFIED OTHERWISE:
   ALL RESISTORS IN OHMS, ± 1%, 1/4W.
   ALL CAPACITORS IN MICROFARADS, 100V

6-2

Figure 6-2. Regulator Board, A3



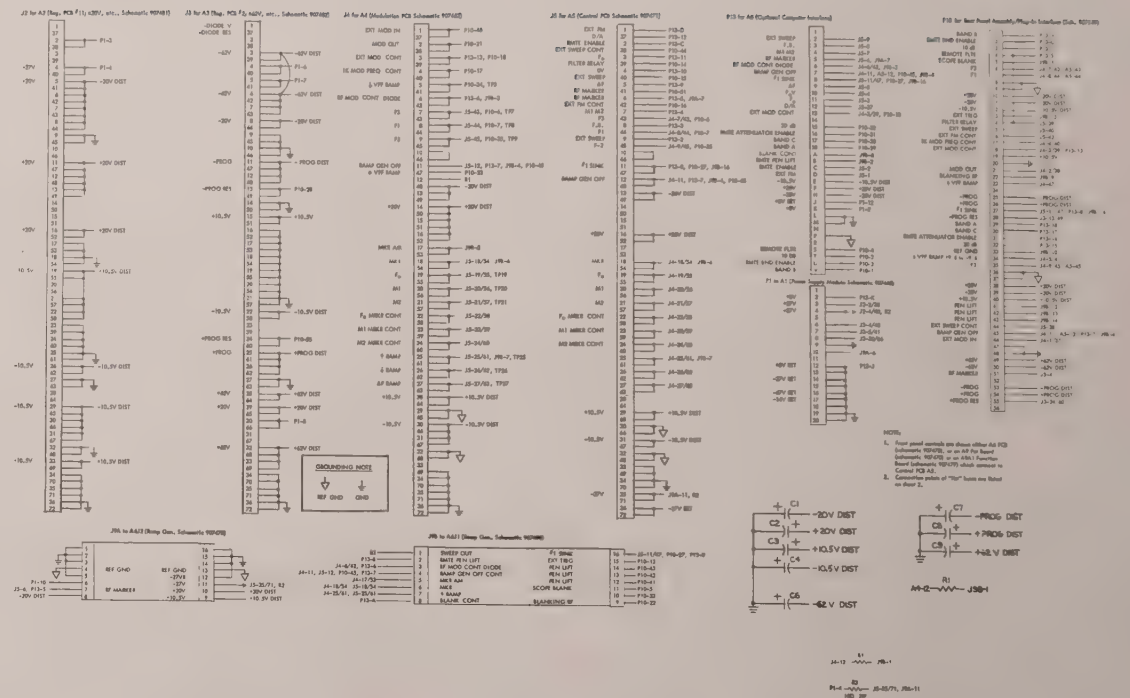
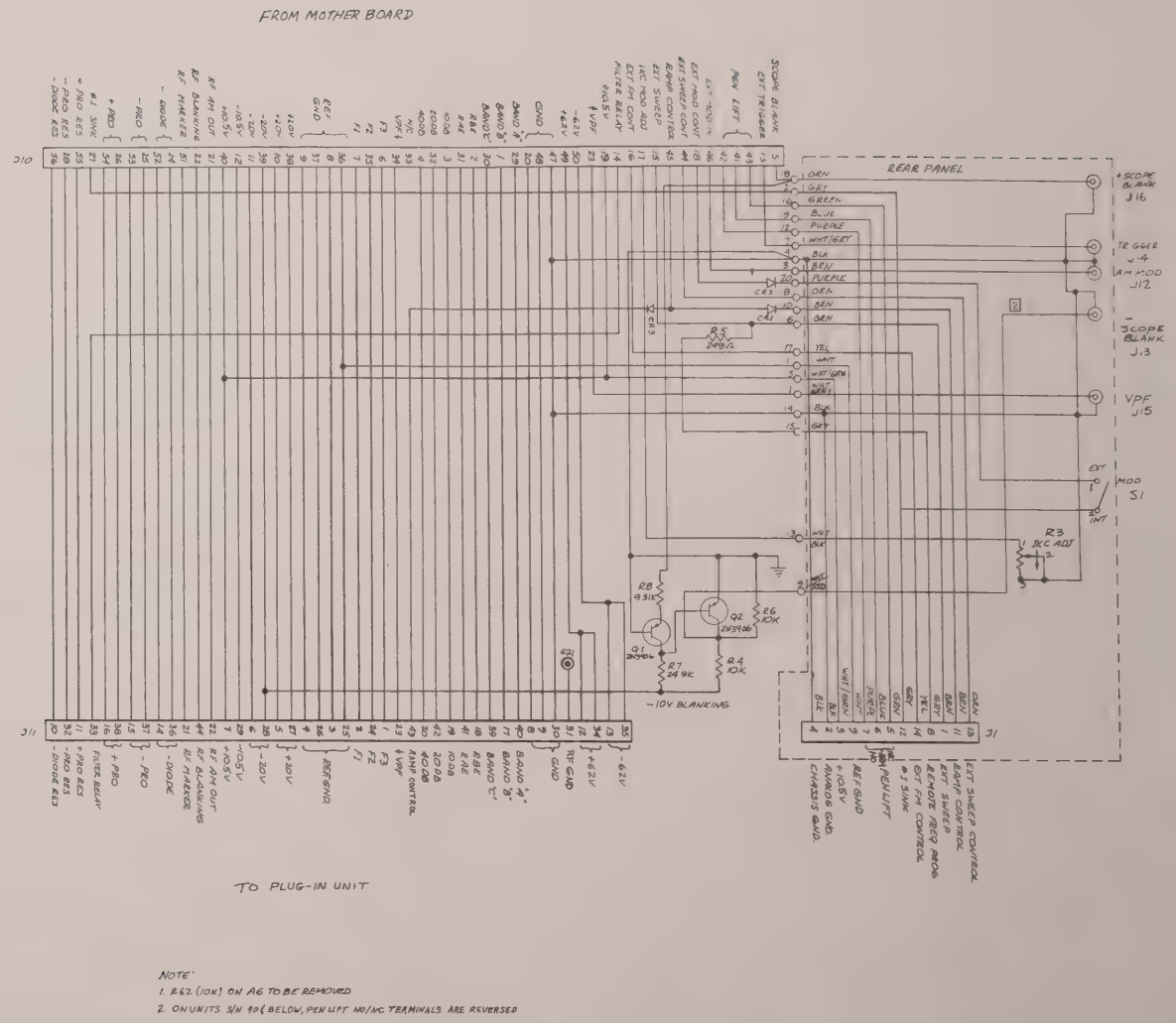


Figure 6-3. Mother Board, A10



NOTE:
1. R62 (10K) ON A6 TO BE REMOVED
2. ON UNITS S/N 90{ BELOW, PEN LIFT NO/NC TERMINALS ARE REVERSED

Figure 6-4. Rear Panel Assembly, A7

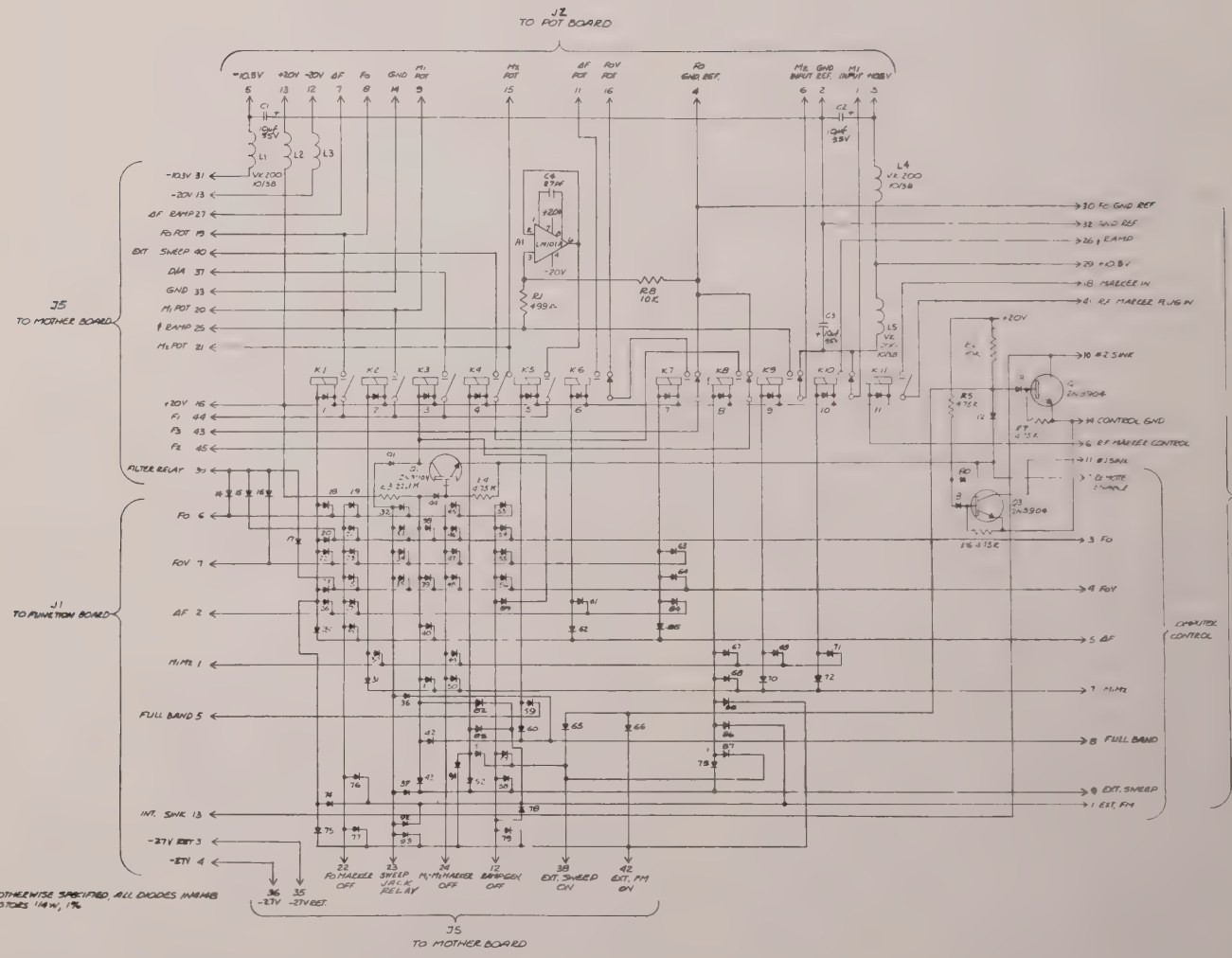
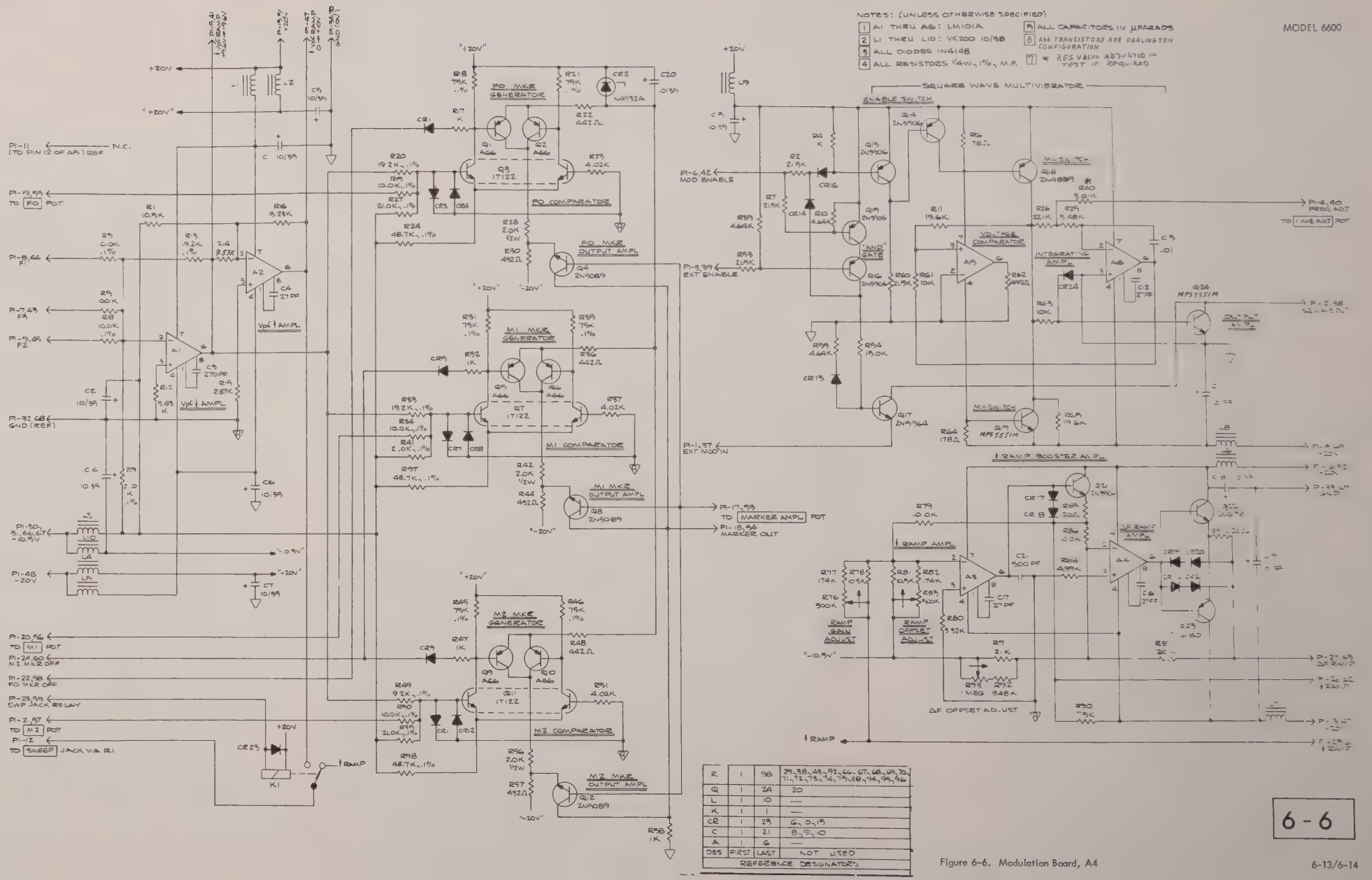


Figure 6-5. Control Board, A5

A5

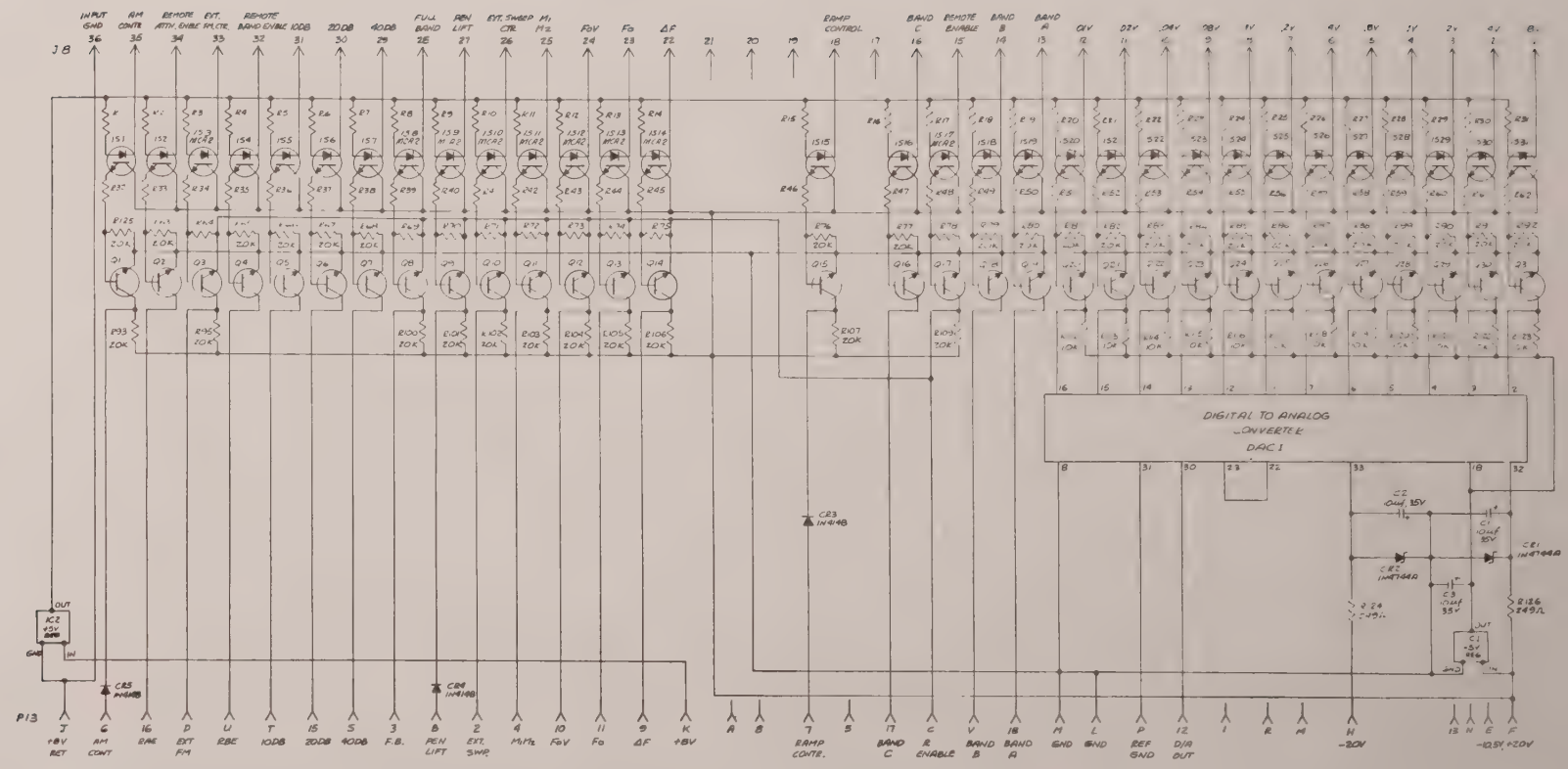
6-5

NOTES: (UNLESS OTHERWISE SPECIFIED)
1. A1 THRU A6: LM101A
2. L1 THRU L10: VK200 10/5B
3. ALL DIODES IN4148
4. ALL RESISTORS 1/4W, 1%, M.F.
5. ALL CAPACITORS IN MFARADS
6. A66 TRANSISTORS ARE DARLINGTON CONFIGURATION
7. * RES VALUE ADJUSTED IN TEST IF REQUIRED



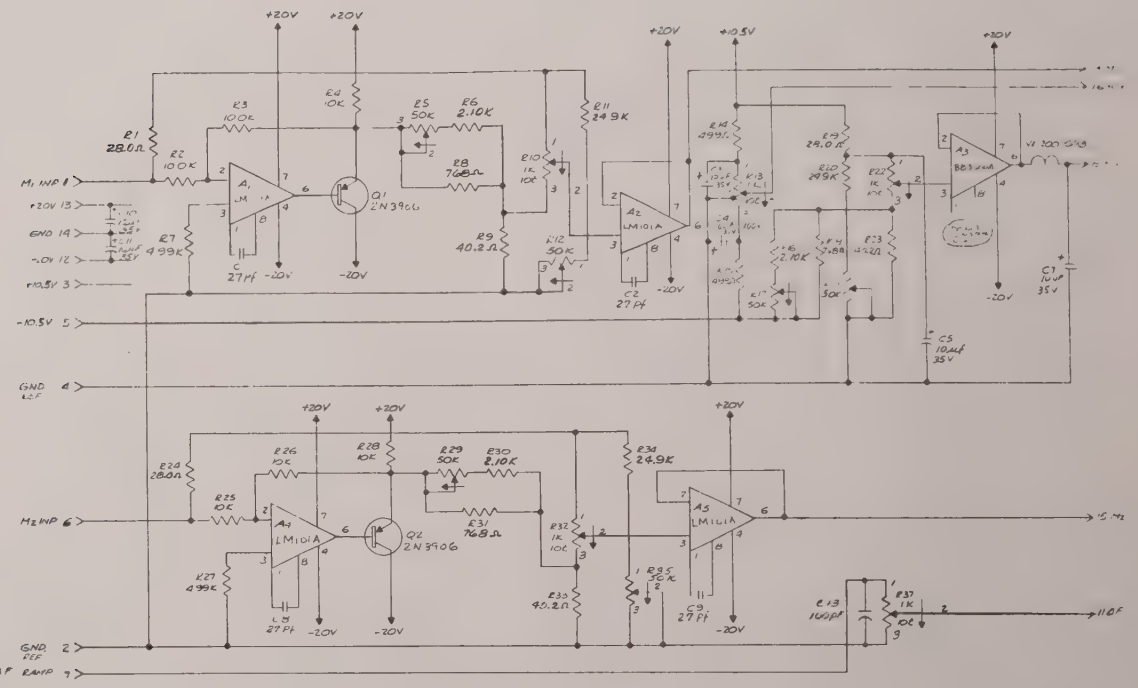
R	1	98	29, 38, 43, 52, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 88, 94, 95, 96
Q	1	24	20
L	1	10	—
K	1	1	—
CR	1	23	6, 9, 15
C	1	21	8, 9, 10
A	1	6	—
DBS	FIRST	LAST	NOT USED
REFERENCE DESIGNATORS			

Figure 6-6. Modulation Board, A4



NOTE
UNLESS SPECIFIED OTHERWISE:
1. ALL RESISTORS 2.0K, 1/4W, 1%
2. ALL CAPACITORS IN MICROFARADS
3. ALL TRANSISTORS 2N3904
4. ALL OPTICAL ISOLATOR MCT 26

Figure 6-7. Computer Board, A8



NOTE:
1. ALL FIXED RESISTORS 1/4W, 1% METAL FILM.
2. ALL CAPACITORS 100V UNLESS OTHERWISE NOTED

NOT USED	
C12	R36
C60	

A9

6-8

Figure 6-8. Pot Board, A9

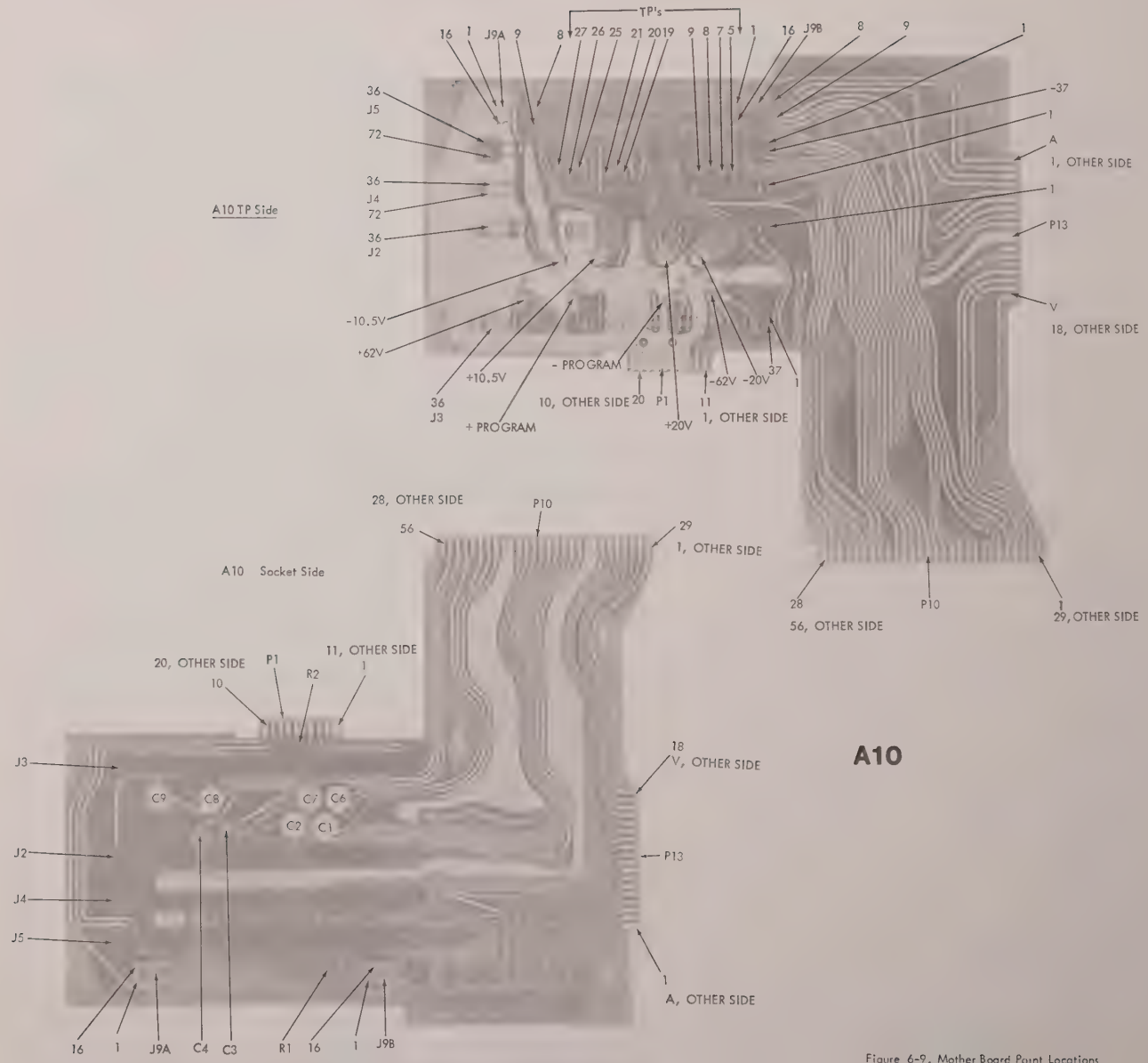


Figure 6-9. Mother Board Point Locations

SHIPMENT DAMAGE CLAIM

The instrument should be tested as soon as it is received. If it fails to operate properly or is damaged in any way, a claim must be filed with the carrier. Have carrier agent inspect damage to instrument and packing crate and forward us a copy of his written report. You will then be advised of replacement or repair arrangements and disposition of the equipment. Please include model number, type number and serial number when referring to this instrument for any reason.

REPACKING FOR SHIPMENT

The instrument should be packed in the original carton. If unusable or not available, use a wooden box with approximately three inches of excelsior or other shock-absorbing material surrounding the instrument. If desired, packing services of a local transfer and storage company may be employed.

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